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# PROCEEDINGS OF THE 1966 COTTONSEED PROCESSING CLINIC

Held at New Orleans, La.  
February 7 and 8, 1966

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## FOREWORD

The Agricultural Research Service of the U. S. Department of Agriculture wants to be sure that the nation will receive maximum benefit from its research programs. Utilization research is constantly developing new ideas and products that show great possibilities of benefiting growers, industry, and consumers.

The Cottonseed Processing Clinic is sponsored annually by the Southern Utilization Research and Development Division in cooperation with the Mississippi Valley Oilseed Processors Association, Inc. Its purpose is to acquaint representatives of the cottonseed industry with current developments in utilization research and to provide an exchange of information that will benefit future research.

These proceedings report the statements presented by the various speakers during the 1966 Clinic and give an account of the discussions during the three sessions.

C. H. Fisher

Director, Southern Utilization Research and Development Division

GENERAL CHAIRMAN

R. C. Woodruff

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CONFERENCE COORDINATOR

B. A. Sharar

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## WELCOME

by  
C. H. Fisher, Director  
Southern Utilization Research  
and Development Division

It is a pleasure to welcome all of you, old friends and new, to the 1966 Cottonseed Processing Clinic.

We in the Southern Utilization Research and Development Division are happy to have the privilege of sponsoring these Clinics in cooperation with the Mississippi Valley Oilseed Processors Association.

Topics discussed at these Clinics in the preceding 14 years have changed with the changing situations confronting the cottonseed industry. Our program for this fifteenth Clinic comprises a number of subjects unthought of when the first one was held, but these subjects have been chosen for their unusual importance, and they will be dealt with by speakers well qualified in the specific areas to be discussed.

I feel sure that this Clinic, like the previous ones, will be both interesting and helpful.

The year 1966 is a special one for agriculture and agricultural research. It is a year also of special significance for our Division, because this is the twenty-fifth anniversary of the opening of the Southern Regional Research Laboratory.

One of the most significant changes to come about since the initiation of a coordinated program of utilization research in the Department of Agriculture, including the founding of the Southern Division, is the change in the philosophy back of agricultural research apparently taking place. At that time--25 years ago--the principal goal was to find outlets for our surplus farm products.

Also, during the period since World War II, agriculture and agricultural research took a back seat to more glamorous fields of endeavor, such as nuclear physics and space exploration.

Now, suddenly, we find that surpluses are disappearing. In fact, lint cotton is the only major crop still in surplus, and indications are that the lag between the world

production of food and world needs will increase as this century draws to a close.

There are several reasons for this. The first is, of course, the population explosion. It is only recently that there has been a general awakening to the imminent threat of a worldwide shortage of food and fiber to meet the requirements of the increasing numbers of people. Large sections of Asia, Africa, and Latin America, where population gains are outstripping gains in food production, are the areas facing the most critical shortages.

Exports may be greatly increased because of world food needs. This should have a major impact on American agriculture.

On the brighter side, some developing areas are expected to achieve advances in their economic situation which will permit their people to improve their daily diet to a small extent, largely in protein foods and fats. Even a small increase for half a billion people will create a tremendous demand.

We seem to be entering a new era in which food and agriculture may acquire a new position of increased importance. Cotton may occupy a unique position in this new era, because it is the only major world crop that provides both food and fiber. Moreover, cotton is already growing in many parts of the world where the need is greatest, particularly for oils and protein foods.

Thanks to research and development, we are in a better position than ever before to meet the challenges of this new era. We have made great progress in understanding and solving our cotton and cottonseed problems. We have accumulated much basic information about the components of cottonseed, both the good and the bad.

We know a great deal about the structure of the cottonseed and the location and composition of its proteins and oil, and we are learning more every day. This basic information may bring about vast changes in the utilization of cottonseed.

We know more about the properties and behavior of gossypol, the cyclopropenoid acids, and the proteins in cottonseed--how to remove or inactivate the undesirable components, and how to use the valuable ones more effectively.

Mycotoxin research is relatively new; so new, in fact, that when we began studying aflatoxin in cottonseed it was necessary first to develop a suitable method of analysis. This has been done, and further progress has been made in these studies.

As I mentioned earlier, this year the Southern Utilization Research and Development Division celebrates its twenty-fifth anniversary and is approaching the 4,000 mark in technical publications and patents. Last year alone, scientists and engineers of the SURDD reported their research in 221 publications and 54 patent applications.

Each year several of the new research developments are commercialized through cooperative efforts of the Southern Division and industry. Some of the research developments adopted for practical use during the past year are: improved cotton batting, analytical methods for aflatoxins, new chemical treatments to further improve the properties of cotton and its position in the market; new machines for the cotton textile industry; and new data to improve efficiency and product quality in the cotton textile mills.

Our scientists and engineers continue to receive recognition in the form of special honors. Examples for the past year are:

Aaron M. Altschul, recent recipient of the Golden Peanut Award, was selected for the Charles F. Spencer Award for outstanding achievement in agricultural chemistry with emphasis on plant proteins.

John D. Guthrie and Wilson A. Reeves received the John Scott Award in recognition of their contributions to the development of the THPC flame-retardant treatment for cotton. Mr. Reeves and J. David Reid received 1964 "Man of the Year" Awards for distinguished service to southern agriculture, an Award given annually by the "Progressive Farmer." The Award was based primarily on important contributions to wash-wear cotton products.

The Department's Superior Service Award was conferred on the Cotton Batting Research Group (headed by Nestor B. Knoepfler) and the Cotton Card Research Group (headed by Roger Brown). Secretary Orville L. Freeman presented the Awards during a visit to the Southern Laboratory.

A special Award was given to Mr. Knoepfler by the National Cotton Batting Institute, The Textile Waste Association, The National Cottonseed Products Association, and The American Cotton Linters Association for his outstanding contributions to the cotton batting industry.

Three members of the SRRL staff, H. P. Dupuy, Louise S. Lee, and Walter A. Pons, Jr., were given honorable mention in the Bond Award competition sponsored by the American Oil Chemists' Society.

A new species of micro-organisms, *Pichia etchellsii*, has been named for J. L. Etchells. This is the second honor of this kind accorded to Dr. Etchells; previously *Torulopsis etchellsii* was named for him.

Mr. Reeves was chosen by the Federal Business Association of New Orleans as Man of the Year in the Professional and Scientific Category, and James Franklin as Man of the Year in the Wage Board Category.

For any successes we have had we are indebted to our friends in industrial and other organizations. A considerable portion of our cooperative research on cottonseed and linters is supported by funds from the National Cottonseed Products Association, the Foundation for Cotton Research and Education, the Cotton Producers' Institute, National Cotton Batting Institute, Textile Waste Association, and the Office of the Surgeon General. We are grateful for this encouragement and support.

I wish to thank everyone contributing to this conference including:

The officers of Mississippi Valley Oilseed Processors Association; our General Chairman and Session Chairman; the Program Committee and the Speakers; the staff of the Southern Utilization Research and Development Division; and, particularly, each member of this splendid audience.

## OPENING REMARKS

by

N. P. Bartmess, President  
Mississippi Valley Oilseed Processors  
Association, Inc.

As president of your Mississippi  
Valley Oilseed Processors Association

this year, I've learned that one of my most important functions is that of communication.

Today, let me turn directly to Dr. Fisher and his staff and communicate our thanks once again for their continued efforts in research and for preparing this annual clinic which benefits our industry so greatly.

I know their program will be interesting, instructive, and very worthwhile. The

education we will receive from it will be important of course. None of us have stopped learning.

There are great benefits in having just a little more knowledge. I'm certain we'll gain substantially more than just a little knowledge from Dr. Fisher and his staff.

Again, I say thanks to them and wish all of you a pleasant and productive 2 days here at the clinic. Thank you.

## Session I

L. H. Hodges,<sup>1/</sup> Chairman

# FAT EMULSIONS FOR INTRAVENOUS NUTRITION

by

W. S. Singleton

Oilseed Crops Laboratory

Southern Utilization Research and Development Division

Fat emulsions for intravenous nutrition have intrigued many investigators, and a considerable fund of information relative to this subject is available. This report will present a brief background of the need for a product of this type and some of the highlights of the investigations at the Southern Utilization Research and Development Division into the development of emulsifiable fats and oils for use in emulsions for intravenous nutrition.

The medical profession today has many drugs and assorted materials for intravenous therapy--minerals, vitamins, proteins, carbohydrates, and others. For nutritional purposes, that is, for supplying calories, the carbohydrates are the materials of choice. However, the need exists for more calories than can be furnished by the carbohydrates for the proper care of those patients who cannot receive sufficient calories by oral nutrition. Ideally an intravenous solution should be able to supply a high caloric value in relatively small volume. Because of the high caloric value of fats, an emulsified fat seems to be well suited for meeting this need. In the search for a physiologically safe, utilizable fat emulsion, the Southern Division has investigated the development of suitable oil and emulsifier components of emulsions and the physical and chemical properties of emulsions.

In general terms, an emulsion consists of an oil phase dispersed into an aqueous phase with the aid of an emulsifying agent or agents. The means of obtaining the most satisfactory oil and emulsifying agent have required most of the investigative effort. A variety of natural oils representing 6 different oilseeds were processed by many methods. These oils included peanut, soybean, sesame, olive, safflower, and cottonseed. None of these oils has been completely satisfactory as a component of an emulsion, although a specially selected commercial cottonseed oil for a time appeared to be the best. Recent investigations have shown that a specially fractionated, solvent extracted cottonseed oil appears to be superior to all oils tested. Some discussion of the details of the processing of this oil is in order.

Fresh cottonseed were dehulled, cracked, and flaked, and oil was extracted from the flakes with petroleum ether at room temperature. At this step of the procedure and at all subsequent steps, it was desirable to avoid temperatures much above room temperature to avoid fixation of the pigments. The extracted oil was then refined and washed.

Pigments and minor components of the refined oil were removed by the process of adsorbent fractionation at room temperature. Bleaching earth (20 percent based on oil

<sup>1/</sup> Barrow-Agee Laboratories, Inc.

weight) was added to a hexane solution of the oil, and the mixture was stirred for 15 minutes, then filtered. The oil solution was fractionated by column chromatography on active alumina at a ratio of 1:1) alumina: oil, with hexane as the eluting solvent. Solvent was stripped from the eluted oil, after which the oil was deodorized.

The color and composition of the processed oil were determined by light transmission and by thin layer chromatography, respectively. Light transmission of the oil was 98.2 percent, compared to distilled water (100 percent). The oil therefore approximated the appearance of distilled water. Its composition was essentially a mixture of triglycerides without the fatty acids and partial glycerides which normally are present in cottonseed oils.

The emulsifying agent is another of the critical components of a fat emulsion and must be nontoxic, in addition to functioning as a stabilizer of the dispersed oil. Many such agents were investigated, and the most success has been achieved with egg yolk lecithin.

The method which was developed for obtaining pure lecithin from egg yolk involved extraction of yolk phosphatides, followed by fractionation on alumina for isolating the lecithin component. Egg yolks were thoroughly mixed with acetone, and filtered. The filtrate, containing pigmented yolk fat, was discarded. Phosphatides were then extracted from the yolk solids with ethanol. The ethanolic solution of phosphatides was evaporated to dryness and the dried phosphatides were dissolved in petroleum ether and then precipitated by the addition of acetone with recovery air filtration. These phosphatides were then fractionated on alumina by column chromatography, whereby the lecithin component was obtained as a pure material.

For preparation of 1 kilogram of the emulsion of waterwhite cottonseed oil, 10 grams of pure lecithin was dissolved in 200 grams of the oil. Distilled water containing 2 percent of glycerol was the aqueous phase. The two phases were mixed by stirring and then homogenized at an applied pressure of about 4,500 pounds per square inch. After

several cycles through the homogenizer, the emulsion was bottled and sealed, then sterilized at 121°C. for 17 minutes.

The distribution of dispersed oil particles as a function of particle diameter was determined by electronic counting. Most of the dispersed oil was in the form of particles whose diametric size was between 1 and 2 microns.

Emulsions prepared with water-white cottonseed oil and purified egg lecithin have received considerable testing in animals, with very satisfactory results. It is anticipated that this product will soon be available for clinical evaluation.

## DISCUSSION

Question: Mr. Singleton, I remember reading some articles in the past where people were feeding a higher concentration of unsaturated components, and my question to you would be, I wonder if anything like winterized cottonseed oil would be more significant in this application than whole cottonseed oil.

Mr. Singleton: Yes, it would be. I trust everyone is aware of the question. The question was, would winterized oil be better than a nonwinterized oil?

It would be if one considers the possibility of an extremely cold storage of these products; also, that there might be some indication that unsaturated materials could be more readily utilized by the body than the saturated materials.

The idea of winterizing the oil has not been sidetracked. We merely wanted to get, let's say, as drastic a test of the product as possible with the idea then of further improvements being on the easier side rather than being more difficult.

# A SIMPLIFIED PROCESS FOR THE ELIMINATION OF THE HALPHEN-TEST RESPONSE IN COTTONSEED OILS <sup>1/</sup>

by

E. T. Rayner, Oilseed Crops Laboratory  
P. H. Eaves, Engineering and Development Laboratory  
L. E. Brown and H. P. Dupuy, Oilseed Crops Laboratory  
Southern Utilization Research and Development Division

(Presented by H. P. Dupuy)

## Introduction

In two recent reviews on cyclopropenoids (1,2), it was pointed out that a number of investigators have shown that many oilseeds such as cottonseed contain cyclopropenoid (malvalic and sterculic) acids in their triglycerides. Although the concentration of these cyclopropenoids in cottonseed oil is relatively small (3,4,5,6), the incorporation of low levels of cottonseed oil into the diet of laying hens results in certain biological effects, such as production of eggs having pink whites, decreased pH of whites, increased pH of yolks, enlarged mottled yolks upon storage (1,2), and lower ratios of oleic acid to stearic acid in yolk lipids or tissue lipids (7,8,9,10).

However, if these cyclopropenoids are inactivated before being ingested by laying hens, the biological effects are no longer observed (10,11). Therefore, the cottonseed industry has become interested in the development of an economical method of producing cottonseed oils that are essentially free of cyclopropenoids. This paper reports a simplified process for the inactivation of cyclopropenoids in alkali-refined cottonseed oils.

## Materials and Equipment

Commercial, refined, Halphen-positive cottonseed oil containing about 0.57 and 0.66 percent cyclopropenoids (calculated as malvalic acid); commercial corn salad oil (Corn Products Company, Mazola); crystallized distilled cottonseed oil super grade alkyl acids (Armour and Company, Neo Fat 140); distilled capric acid (Armour and Company, Neo Fat 10); anhydrous powder citric acid (Baker analyzed reagent grade); 85 percent phosphoric acid (Baker analyzed reagent grade); chromatographic alumina (Alcoa F-20 80-200 mesh); bleaching earth (AOCS Natural Bleaching Earth); and glass wool fiber (Pyrex No. 3950) were used.

The laboratory deodorizer for fats and oils described by Bailey and Feuge (12) was modified by removing the spray trap, inserting a thermometer well into the Claisen-type distilling flask, enlarging the base of the first dry-ice condenser, and installing the inlet near the base of the first dry-ice condenser and the outlet near the base of the second dry-ice condenser.

The fatty acid methyl esters from egg yolk lipids were analyzed in a Jarrell-Ash gas-liquid chromatograph, model 28-700, equipped with a flame-ionization detector and 1/4 inch by 6 feet stainless steel column packed with 18 percent ethylene glycol succinate on acid-washed Chromosorb W (80-100 mesh). The instrument was calibrated with a KD (lot 568-38) reference standard from Applied Science Laboratories and also with GLC reference mixture No. 1 from Hormel Institute.

## Laboratory Experimental Procedures and Results

### Partial Inactivation of the Cyclopropenoids in Cottonseed Oil by Heat Treatment

In a 1-liter laboratory deodorizer (12) 370 grams of commercial cottonseed oil containing 0.66 percent cyclopropenoids were heated at 235°C. for 1 hour with a small flow of nitrogen sparging through the mixture. The flow of nitrogen was discontinued, and the cottonseed oil was steam deodorized (12) at 235°C. for 1 hour at a pressure of 1 millimeter to eliminate the volatile substances. The oil had a positive response to the Halphen test (13). When the oil was analyzed by the stepwise HBr titration method (6), the titration value for cyclopropenoids was 0.15 percent (calculated as malvalic acid). The concentration of free fatty acids obtained for the oil was 0.02 percent (13) calculated as oleic acid.

<sup>1/</sup> Presented, in part, at the American Oil Chemists' Society Meeting, Houston, Tex., April 1965.

When the oil was heated for 2 hours at 235°C. followed by deodorization at 235°C. for 1 hour, the titration value for cyclopropenoids was reduced to 0.04 percent. However, since the oil still had a positive response to the Halphen test, it was not assayed for biological effects with laying hens.

#### Elimination of the Halphen-test Response in Cottonseed Oil by Treatment With Acids

**Cottonseed oil fatty acids and capric acid.** --In a modified 5-liter laboratory deodorizer, 1,850 grams (2.14 moles) of the commercial cottonseed oil containing 0.66 percent cyclopropenoids and either 49 grams of cottonseed oil fatty acids (4 equivalents based on cyclopropenoid concentration) or 46 grams of capric acid (6 equivalents based on cyclopropenoid concentration) were heated at 235°C. for 2 hours with a small flow of nitrogen sparging through the mixture. The flow of nitrogen was discontinued, and the treated cottonseed oil was steam deodorized (12) at 235°C. for 1 hour at a pressure of 1 millimeter to eliminate the volatile substances, including excess free fatty acids. Oil treated with either cottonseed oil fatty acids or capric acid had a negative response to the Halphen test (13). When oil treated by either acid was analyzed by the stepwise HBr titration method (6), the titration value for cyclopropenoids was 0.01 percent (calculated as malvalic acid). This value is within the sensitivity limits of the method. The concentration of free fatty acids obtained for both oils was 0.02 percent (13) calculated as oleic acid. The results of additional experiments with varying equivalents of both acids show that in comparison with cottonseed oil fatty acids, a higher molar concentration of capric acid was required to achieve the same effect, perhaps because of its greater volatility (table 1).

The salient features to be noted, however, are that either the higher molecular weight cottonseed oil fatty acids or the lower molecular weight capric acid completely inactivates the cyclopropenoids in alkali-refined cottonseed oil, and that the resulting oil is light in color.

**Citric acid.** --In a 5-liter round-bottom flask equipped with stirrer, thermometer, and inert gas inlet, 1,850 grams (2.14 moles) of the commercial cottonseed oil containing 0.66 percent cyclopropenoids and 37 grams of citric acid (13 acid equivalents based on cyclopropenoid concentration) were stirred and heated at 235°C. for 2 hours under a nitrogen atmosphere. The treated oil was cooled to room temperature and filtered through a thin layer of glass wool to remove dispersed particles. After steam deodorization as described above, the oil had a negative response to the Halphen test. The titration value for cyclopropenoids was 0.01 percent.

Although the citric acid treatment is effective and the treated oil is light in color, the monofunctional fatty acid treatments appear to be more promising in that these fatty acids are readily soluble in the oil; they do not tend to char in the oil; and they do not promote the formation of dispersed particles requiring filtration.

**Phosphoric acid.** --In a 5-liter round-bottom flask equipped with stirrer, thermometer, and inert gas inlet, 3,000 grams (3.5 moles) of the commercial cottonseed oil containing 0.66 percent cyclopropenoids was bleached with 166 grams of AOCs Official Natural Bleaching Earth (13).

In a 5-liter round-bottom flask equipped as above, 2,820 grams (3.26 moles) of the bleached cottonseed oil and 25 grams of 85

Table 1. --Elimination of the response of the Halphen test in cottonseed oil by heat treatment<sup>1/</sup> in the presence of cottonseed oil fatty acids or capric acid

| Acid equivalents <sup>2/</sup> | Percent of cyclopropenoids <sup>3/</sup> |             | Response of Halphen test |                 |
|--------------------------------|------------------------------------------|-------------|--------------------------|-----------------|
|                                | Cottonseed acids                         | Capric acid | Cottonseed acids         | Capric acid     |
| 2                              | 0.02                                     | 0.03        | +                        | +               |
| 4                              | .01                                      | .02         | -                        | + <sup>4/</sup> |
| 6                              | .01                                      | .01         | -                        | -               |
| 8                              | .01                                      | .01         | -                        | -               |

<sup>1/</sup> Heated for 2 hours at 235°C. followed by deodorization at 235°C. for 1 hour.

<sup>2/</sup> Based on the equivalent concentration of cyclopropenoids.

<sup>3/</sup> Determined by HBr titration (6) and calculated as malvalic acid.

<sup>4/</sup> This response was only slightly positive, if at all.

percent phosphoric acid (10 acid equivalents based on cyclopropenoid concentration) were stirred and heated at 180°C. for 1 hour under a nitrogen atmosphere. The treated cottonseed oil was cooled to room temperature and percolated through an activated alumina column (1,400 grams alumina gravity packed in a 10 centimeter I. D. column) to remove excess phosphoric acid, fatty acids, and colored material. This treatment produces an oil which is unusually light in color. After steam deodorization as described above, the oil had a negative response to the Halphen test. The titration value for cyclopropenoids was 0.01 percent.

Although this process would not provide a practical approach for the inactivation of the undesirable cyclopropenoids in cottonseed oil, preliminary evidence indicates that it does eliminate the cyclopropenoid-phosphoric acid reaction products from the treated oil (14). Since the previously mentioned processes utilizing cottonseed oil fatty acids, capric acid, or citric acid do not eliminate the cyclopropenoid reaction products from the oil, treatment of cottonseed oil with phosphoric acid provides an excellent control oil, relatively free of such reaction products (14), for use in biological studies.

#### Biological Assay of Treated Halphen-Negative Cottonseed Oils

Six groups of five young-adult pedigreed White Leghorn hens were caged individually in a sanitary air-conditioned animal room. They were fed ad libitum for 10 days on a basal ration with the following percentage composition: ground corn, 60; soybean meal (50 percent protein), 30; alfalfa leaf meal (17 percent protein), 5; ground limestone, 2; bone meal, 1; corn distillers solubles, 1; and iodized salt, 0.5. To each pound of the mixture, the following compounds were added: manganese sulfate, 55 milligrams; vitamin B<sub>2</sub>, 850 micrograms; vitamin B<sub>12</sub>, 15 micrograms; choline, 120 micrograms; vitamin A, 2,000 IU; and vitamin D<sub>3</sub>, 495 ICU.

Each group of hens was then fed different experimental rations prepared by supplementing the basal ration with 5 percent of one of the following oils: (1) corn oil, (2) commercial alkali-refined cottonseed oil containing 0.66 percent cyclopropenoids, (3) Halphen-negative cottonseed oil prepared from the commercial cottonseed oil by heat treatment

with cottonseed oil fatty acids, (4) capric acid, (5) citric acid, and (6) phosphoric acid.

After each group of hens had been fed its respective experimental ration for a period of 2 weeks, collection of eggs was begun. Twelve eggs were collected from each hen and stored at 1° to 5° C. After 3 months' storage, each odd-numbered egg was analyzed for pH of the white, pH of the yolk, and discoloration of the white. After being stored for 6 months, each even-numbered egg was analyzed for pH of the white, pH of the yolk, and discoloration of the white.

As shown in table 2, the pH of the white of the stored eggs produced by hens fed the ration supplemented with 1 of the treated Halphen-negative cottonseed oils was almost comparable to the pH of the white of the stored eggs produced by hens fed the ration supplemented with corn oil, whereas the pH of the white of the stored eggs produced by hens fed the ration supplemented with Halphen-positive cottonseed oil was decreased about 0.5 pH unit. In addition, the pH of the yolk of the eggs produced by hens fed the basal ration supplemented with one of the treated Halphen-negative cottonseed oils was comparable to the pH of the yolk of the eggs produced by the hens fed the basal ration supplemented with corn oil, but the pH of the yolk of the eggs produced by hens fed the basal ration supplemented with the Halphen-positive cottonseed oil was increased almost 2 pH units. In other words, the difference of about 2 pH units which is normally found between the white and yolk of eggs was reduced to about 0.1 pH unit in the eggs produced by the hens fed the basal ration supplemented with the Halphen-positive cottonseed oil. The marked decrease of pH difference between the white and yolk of eggs results from diffusional processes which occur in disordered eggs (15).

In appearance, the white and the yolk of the eggs produced by hens that ingested corn oil do not differ markedly from the white and yolk of eggs produced by hens that ingested the various treated Halphen-negative cottonseed oils. However, the white and yolk of the eggs produced by hens that ingested Halphen-positive cottonseed oil are characterized by pink discoloration of the whites, and enlarged, mottled yolks, caused respectively by diffusion of material from the

Table 2. --pH of stored eggs from hens fed basal ration supplemented with 5 percent oil

| Oil        |                  | pH after 3 months |      | pH after 6 months |      |
|------------|------------------|-------------------|------|-------------------|------|
| Type       | Treatment        | White             | Yolk | White             | Yolk |
| Corn       | Negative control | 8.82              | 6.58 | 8.79              | 6.73 |
| Cottonseed | Positive control | 8.46              | 8.32 | 8.40              | 8.32 |
| Cottonseed | Cottonseed acids | 8.99              | 6.52 | 8.83              | 6.56 |
| Cottonseed | Capric acid      | 8.97              | 6.55 | 8.79              | 6.58 |
| Cottonseed | Citric acid      | 8.90              | 6.63 | 8.81              | 6.52 |
| Cottonseed | Phosphoric acid  | 8.95              | 6.65 | 8.71              | 6.63 |

yolk into the white and from the white into the yolk (2).

Wilcke and Steinke (16, 17) of the Ralston Purina Company, have developed an excellent technique to illustrate the latter type of diffusion. Their technique was used to prepare the boiled eggs shown in figure 1. The mass diffusion of material from the white into the yolk is apparent in the quarter-sectioned egg on the left. This egg was produced by

acid patterns in the oils are comparable for the untreated refined cottonseed oil, which contained about 0.66 percent cyclopropenoids, and the 4 treated cottonseed oils (table 3), the patterns in the lipids of the egg yolks differed. As shown in table 4, hens that ingested one of the treated cottonseed oils produced eggs with a fatty acid pattern in the yolk lipids similar to that of eggs produced by the hens that ingested corn oil. However, hens whose ration was supplemented with



Figure 1.--Two quarter-sectioned boiled eggs prepared by the method of Wilcke and Steinke (16,17). The egg on the left produced by a hen that had ingested alkali-refined, Halphen-positive cottonseed oil, shows the mass diffusion of material from the white into the yolk. In contrast, there is no diffusion of material from the white into the yolk of the egg on the right, produced by a hen fed alkali-refined cottonseed oil that had been treated with cottonseed oil fatty acids.

a hen whose ration was supplemented with Halphen-positive cottonseed oil. The quarter-sectioned egg on the right, which does not show diffusion of egg-white material into the yolk, was produced by a hen whose ration was supplemented with cottonseed oil treated with cottonseed oil fatty acids.

In addition, the yolks of the odd-numbered eggs from each hen were pooled and fatty acid methyl esters were prepared by inter-esterification of representative samples of the pooled yolk lipids (18). Although the fatty

Halphen-positive cottonseed oil produced eggs that had a much lower oleic acid to stearic acid ratio in the yolk lipids than that of the hens whose ration was supplemented with one of the treated Halphen-negative cottonseed oils. These results are in agreement with the findings of Evans and others (7, 8, 9).

Table 3. --Fatty acid analysis of oils used to supplement basal laying rations

| Oil        |                  | Fatty acid in oils |           |           |           |           |           |
|------------|------------------|--------------------|-----------|-----------|-----------|-----------|-----------|
| Type       | Treatment        | C<br>14:0          | C<br>16:0 | C<br>16:1 | C<br>18:0 | C<br>18:1 | C<br>18:2 |
|            |                  | Percent            | Percent   | Percent   | Percent   | Percent   | Percent   |
| Corn       | Negative control | None               | 11.7      | None      | 2.2       | 27.5      | 57.1      |
| Cottonseed | Positive control | 1.0                | 23.4      | Trace     | 2.3       | 16.8      | 55.4      |
| Cottonseed | Cottonseed acids | 1.4                | 20.1      | Trace     | 1.9       | 16.1      | 59.4      |
| Cottonseed | Capric acid      | 1.0                | 23.4      | Trace     | 2.0       | 16.2      | 57.1      |
| Cottonseed | Citric acid      | 0.8                | 22.5      | Trace     | 2.5       | 17.2      | 55.9      |
| Cottonseed | Phosphoric acid  | 1.1                | 23.1      | Trace     | 2.9       | 17.6      | 54.4      |

Table 4. --Fatty acid analysis of eggs from hens fed basal ration supplemented with 5 percent oil

| Oil        |                  | Fatty acids in yolk lipids |           |           |           |           |           |
|------------|------------------|----------------------------|-----------|-----------|-----------|-----------|-----------|
| Type       | Treatment        | C<br>14:0                  | C<br>16:0 | C<br>16:1 | C<br>18:0 | C<br>18:1 | C<br>18:2 |
|            |                  | Percent                    | Percent   | Percent   | Percent   | Percent   | Percent   |
| Corn       | Negative control | Trace                      | 25.4      | 2.03      | 10.2      | 36.9      | 26.1      |
| Cottonseed | Positive control | 0.63                       | 28.4      | Trace     | 20.7      | 23.6      | 26.7      |
| Cottonseed | Cottonseed acids | Trace                      | 26.2      | 1.92      | 10.7      | 34.9      | 26.8      |
| Cottonseed | Capric acid      | Trace                      | 25.8      | 1.96      | 10.3      | 34.1      | 28.1      |
| Cottonseed | Citric acid      | Trace                      | 25.3      | 1.56      | 10.7      | 36.8      | 26.2      |
| Cottonseed | Phosphoric acid  | Trace                      | 25.9      | 1.90      | 9.9       | 36.1      | 26.7      |

#### Preliminary Pilot-Plant Experimental Procedures and Results

##### Elimination of the Halphen-test Response in Cottonseed Oil by Treatment With and Without the Addition of Cottonseed Oil Fatty Acids

Addition of cottonseed oil fatty acids. -- In a batch-type, pilot-plant deodorizer, 422 pounds (191.5 kilogram) of commercial cottonseed oil containing 0.57 percent cyclopropenoids and 9.6 pounds (4.4 kilogram) of cottonseed oil fatty acids (4 equivalents based on cyclopropenoid concentration) were gradually heated to a maximum temperature of 218°C. (425°F.) within 3.3 hours with a small flow of nitrogen sparging through the mixture under a reduced pressure of 75 to 125 millimeters. An aliquot of the treated oil had a negative response to the Halphen test (13), and the HBr titration value (6) was 0.01 percent. The flow of nitrogen was discontinued, and the treated cottonseed oil was steam deodorized (3.8 pounds of steam per hour, per 100 pounds of oil) at 235°C. (455°F.) for 2 hours at a pressure of 4 millimeters. The concentration of free fatty acids obtained for this oil was 0.17 percent (13) calculated as oleic acid.

An analogous experiment with a small steam sparge (0.7 pound of steam per hour, per 100 pounds of oil) at a reduced pressure of 200 millimeters in lieu of the nitrogen sparge, produced a Halphen-negative oil by gradual heating to a maximum temperature of 224°C. (435°F.) within 2.5 hours. The treated cottonseed oil was steam deodorized (4 pounds of steam per hour, per 100 pounds of oil) at 230°C. (446°F.) for 2 hours at a pressure of 4 millimeters. The concentration of free fatty acids obtained for this oil was 0.05 percent.

Without addition of cottonseed oil fatty acids. -- In a batch-type, pilot-plant deodorizer, 337 pounds (153 kilograms) of commercial cottonseed oil containing 0.57 percent cyclopropenoids was gradually heated to a maximum temperature of 231°C. (448°F.) within 2.5 hours with a small flow of steam sparging (0.7 pound of steam per hour, per 100 pounds of oil) under a reduced pressure of 265 millimeters. After heating for 1 additional hour at 231°C., an aliquot of the treated oil had a negative response to the Halphen test. The HBr titration value was 0.01 percent. The treated oil was steam deodorized (4.7 pounds of steam per hour, per 100 pounds of oil) at 234°C. (453°F.) for

2 hours at a pressure of 4 millimeters. The concentration of free fatty acids obtained for this oil was 0.02 percent. Since this process effectively generates in situ and maintains in the reactor a sufficient concentration of cottonseed oil fatty acids to inactivate the cyclopropenoids, further research is planned to delineate more closely the optimum operating parameters.

In an analogous experiment without adding cottonseed oil fatty acids, 328 pounds (149 kilograms) of commercial cottonseed oil containing 0.57 percent cyclopropenoids was gradually heated to a maximum temperature of 233° C. (451° F.) within 3 hours with a large flow of steam sparging (4.9 pounds of steam per hour, per 100 pounds of oil) under a reduced pressure of 3 millimeters. After heating for an additional 1.5 hours at 233° C., an aliquot of the treated oil finally gave a negative response to the Halphen test. The HBr titration value of this treated oil was 0.01 percent, and the concentration of free fatty acids obtained for this oil was 0.03 percent. Although this process appears to generate in situ a sufficient concentration of cottonseed fatty acids to inactivate the cyclopropenoids, it is not as efficient as the former process because a considerable amount of the fatty acids generated in situ are volatilized before reaction can occur with the cyclopropenoids.

Although these are preliminary pilot-plant experiments, the results appear to be very promising since the inactivation of cyclopropenoids in cottonseed oil with cottonseed oil fatty acids was effectively accomplished in the pilot-plant under milder conditions than was required in the laboratory.

#### Conclusions

The cyclopropenoids in refined cottonseed oil are partly inactivated by heating under a nitrogen atmosphere at 235° C. for 1 to 2 hours, but the response of the oil to the Halphen test remains positive. However, similar heat treatment in the presence of small concentrations of monofunctional or polyfunctional acids not only reduces the concentration of cyclopropenoids as determined by the HBr titration (6) but also totally inactivates the cyclopropenoids as determined by the Halphen test (13). In addition, feeding tests with laying hens indicate that the four processes using acids eliminate certain biological effects attributed to cyclopropenoids in cottonseed oil.

The simple processes for the reduction or inactivation of the cyclopropenoids in cottonseed oil by heat treatment or heat treatment in the presence of small concentrations of monofunctional fatty acids, such as the addition or generation in situ of cottonseed oil fatty acids, appear to be of considerable industrial interest. Therefore, additional laboratory and pilot-plant investigations and biological assays are planned.

#### Acknowledgments

The biological studies and lipid analyses were carried out by J. J. Birdsall, F. B. Coon, J. K. Punwar, and associates of Wisconsin Alumni Research Foundation under sponsorship of the Southern Regional Research Laboratory. We are grateful for the assistance and advice given by C. H. Fisher, L. A. Goldblatt, C. L. Hoffpauir, H. L. E. Vix, F. G. Dollear, E. L. Skau, R. O. Feuge, V. L. Frampton, E. A. Gastrock, E. L. D'Aquin, W. A. Pons, Jr., W. H. Martinez, L. C. Berardi, and F. L. Carter of Southern Regional Research Laboratory.

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## PROGRESS IN THE COMMERCIALIZATION OF IMPROVED COTTON BATTING THROUGH DEVELOPMENTAL RESEARCH

by

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(Presented by N. B. Knoepfler)

### Introduction

The use of cotton batting in cushioning materials extends back many years; in fact from the saddle through the buggy, the horseless carriage and the automobile, and in traditional or antique through present day furniture and mattresses. Since comfort in cushioning materials is so subjective, cotton batting was accepted as the standard because it offered properties that covered the greatest range of personal preference, it performed well under many varied conditions, and it had a reasonably long service life.

Early cushion batts were made with long staple cotton. As the price of cotton increased, compromises were made wherein the use of linters to replace staple cotton became acceptable. This change was for the better because linters are not only shorter and cheaper than staple cotton, but they have a larger effective diameter and, therefore, are inherently more resilient than staple cotton fibers. The use of shorter fibers in battings introduced a loss in coherence or integrity that was subsequently solved by substituting spinning wastes for staple cotton. Gradually other byproducts from cotton

processing such as motes, sweeps, picker, and fly replaced all of the staple cotton in battings with the usual composition today being 60 percent linters and 40 percent textile wastes for automotive cushioning and 70 percent linters and 30 percent textile wastes for mattresses and furniture.

Until about 1953 cotton batting enjoyed practically a monopoly in the cushioning market. Minor competing materials were moss, kapok, sisal, and curled hair. At about this time the explosion of technical research following World War II was beginning to have a significant impact upon all manufactured goods. Coupled with this situation was the pent-up demand of consumers for manufactured goods, which in the case of cotton products served to drive the price of linters to an alltime high. This left the way open for a penetration of foam rubber into cushioning. Admittedly the price of foam rubber was higher by far than cotton batting even when linters were at an alltime high. The manufacturers found, however, that the dimensional stability and coherence of foam rubber products were so superior to conventional cotton batting that they could recoup part of the cost of the cushioning

material by reducing hand labor inherent with cotton batting products. As the chemical technology of foamed products increased, it became possible to introduce new products that were less expensive than foamed rubber. Of these the most important as a competitor for cotton was polyurethane foam.

It is unfortunate to note that the cotton batting industry, which has been bound by tradition and high labor costs, chose to try to compete with these new products by reducing prices through the substitution of lower grades of fibers rather than by upgrading their product to meet new consumer demands. With this background, it is evident that cotton batting was in serious trouble. Its use in automobiles, for example, had fallen from over 36 pounds per vehicle in 1950 to approximately 20 pounds per vehicle in 1961.

Recognizing the plight of the cotton batting industry, 4 trade associations directly connected with cotton raw materials that are used in cotton batting approached the Southern Regional Research Laboratory with the urgent request that research be undertaken to upgrade cotton batting. The organizations were the Textile Waste Association, the National Cottonseed Products Association, the National Cotton Batting Institute, and the Foundation for Cotton Research and Education. These groups and the U. S. Department of Agriculture joined to sponsor a research project directed at improving cotton batting to better permit it to compete with the new cushioning materials.

### Defining the Problem

Contact with the consumers of cotton batting, the automobile industry, and mattress and furniture manufacturers established the fact that cotton batting needed improvement in resilience, cohesion, and dimensional stability to compete effectively with the new products. Similar contact with the batting manufacturers elicited the information that part of the reductions in quality noted in cotton batting products could be attributed to changes in harvesting, ginning, and spinning practices, which resulted in lower fiber quality with increased amounts of trash. In addition, it was observed that batting manufacturers were operating their equipment at rates of production far in excess of recommended rates. These factors coupled with poorly controlled hand blending,

inadequate cleaning, and the tendency of substituting even lower grade fibers to reduce the price had seriously affected product uniformity, and consequently engendered a poorer regard for cotton batting by the consumers.

These findings from the consumer point of view were summarized and the problem defined as a search for means to give cotton batting a textile structure with better dimensional stability, better coherence or tensile strength, higher bulk with lower weight, and more complete and rapid recovery from deformation loading. From the manufacturers' point of view, the process to achieve the above aims should cause a minimum change in present operating practices, should be economical, and should involve a minimum of capital outlay.

With these considerations in mind a research program was devised which would explore the use of resins or other chemical treatments to enhance the resilience of the individual fibers or the bulk of fibers, adhesives to achieve bonds between fibers which would contribute dimensional stability and tensile strength, and combinations of mechanical and chemical approaches to improve the lay of the fibers in a batting array.

It is obvious that no one product could adequately meet the requirements of all of the end uses of cotton batting. The research program, therefore, included the concept that if a process was devised, it would have to be versatile enough to permit the production of a variety of end-use products.

Development of a process. --Much technical information on means of improving the resilience and the dimensional stability of cotton in textiles was available to the research team through other research carried out at the Southern Regional Research Laboratory. All of this data emphasized the advantages of wet processing. This technology could not be directly applied to cotton batting because in textile operations the cotton fibers are usually scoured and bleached and are, therefore, more receptive to chemical treatment than would be the case with cotton by-products used in cotton batting. Furthermore, it was demonstrated that wet processing of finished cotton batting was not practical and that cotton batting products after treatment could not be washed in the same manner as textile products.

The optimum opportunity to distribute the chemicals uniformly throughout the batting array presented itself during garnetting when the fibers are open in a web form before laminating into the batt. Because of the fragility of the web, immersion treatments did not seem practical, therefore, the alternative of spraying was selected as the means of applying the chemicals.

In assaying the potential of various resin treatments it became evident that the thermosetting water soluble resins could contribute a significant improvement in the resilience of the individual fibers. These resins did not, however, significantly enhance the resilience of the batting array because the individual fibers were still able to move and shift with respect to one another as occurs in conventional cotton batting.

To overcome this shortcoming thermoplastic resins were used. These resins do not react chemically with the cellulose of the cotton, but rather form films on the surface of the fibers. Under the proper conditions the fibers become bonded to one another at the points where they contact each other.

Further evaluation of this thermoplastic-thermosetting resin system showed that if the components were properly selected, the two could be applied from a single solution/suspension simultaneously. Additional research established that the optimum relationship between thermoplast and thermoset resins should be about 1 to 1, or 50 percent of each, and that the concentration of the treating solution should be approximately 20 percent solids. Under these conditions the optimum wet add-on is approximately an equal weight of treating solution to the weight of the cotton. The chemical add-on is 16.6 percent after drying and curing. The criteria for the selection of the resins used were that they be water soluble or suspendible, mutually compatible, of low toxicity, of low cost, and of long pot life. In addition, the resins were screened for their odor potential before and after storage. Table 1 shows typical formulations developed.

The selection of a wet processing system makes facilities for drying the spray damp cotton batting necessary. Furthermore, almost all of the thermosetting resins and some of the thermoplastic resins require a cure at approximately 300°F. for a short period of time.

Table 1. --Typical treating formulations (20 percent solids)

| Treating formulation            | Percent |
|---------------------------------|---------|
| <u>Formulation 1</u>            |         |
| Methylated methylol melamine    | 50      |
| Vinyl acetate                   | 50      |
| Buffer or formaldehyde acceptor |         |
| Catalyst (magnesium chloride)   |         |
| Water                           |         |
| <u>Formulation 2</u>            |         |
| Urea formaldehyde (modified)    | 50      |
| Vinyl acrylate                  | 50      |
| Buffer or formaldehyde acceptor |         |
| Catalyst (magnesium chloride)   |         |
| Water                           |         |
| <u>Formulation 3</u>            |         |
| Methylated methylol melamine    | 50      |
| Vinyl acetate-acrylate          | 40      |
| Styrene butadiene               | 10      |
| Buffer or formaldehyde acceptor |         |
| Catalyst (magnesium chloride)   |         |
| Water                           |         |

The process can be summarized as consisting of spraying the web as it emerges from the garnett with a 20 percent solids solution/suspension of resins to approximately a 100 percent wet add-on, conventional lapping, followed by drying and curing. Figure 1 shows a typical flow diagram.

The properties that have been built into the products are compared with those of untreated cotton batting and with polyurethane foam in table 2. It can be noted that almost all of the initial requirements for the building of an improved cotton batting product have been achieved. It should be noted that one-third less weight of the new product does a much superior job than untreated cotton batting. Costwise the new product is about one-fourth that of polyurethane foam.

Status of commercialization of the process. --It has indeed been a source of satisfaction to the research team carrying out the work on cotton batting to receive the active and continued cooperation of the chemical industry as well as the sponsors of the program, and of the batting industry itself.

Quite early in the program it became evident that many of the chemicals such as are used to achieve wash-wear, permanent

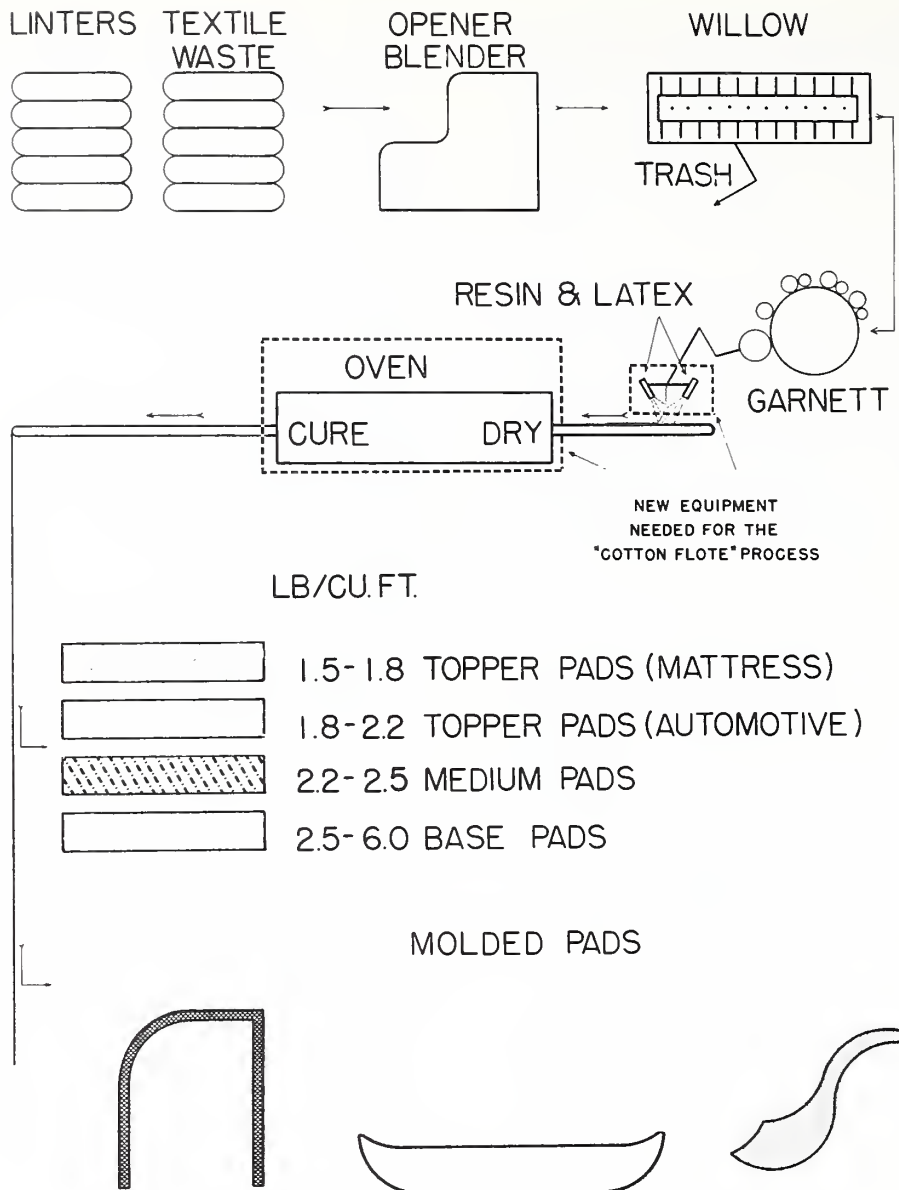


Figure 1.—Flow diagram for preparation of improved cotton batting

press, crease resistance, and resilience in cotton textiles were not the optimum for use in the cotton batting application. Both the manufacturers of the thermosetting and thermoplastic resins made available research quantities of new compounds under development in their laboratories, and actually undertook research on their own to try to develop resins particularly suited for use on cotton batting. Likewise, several of the cotton batting manufacturers, once they became convinced that we were achieving significant improvement in the properties of cotton batting, installed pilot lines in their plants to evaluate our findings on commer-

cial-scale equipment. As the research data was compiled and evaluated, it was disseminated to those plants for verification on their equipment. Once promising samples were produced on full-scale equipment, the 4 major automobile manufacturers were contacted, and at their request samples of full-scale automobile seat cushions were produced and sent to them for evaluation. Information "feed back" to the research team from these samples enabled changes to be made in formulations and processing to achieve what was wanted by the automobile industry. Delivery of commercial quantities to Ford Motor Company commenced on January 14, 1965.

Table 2. --Comparison of cotton flote with conventional cotton batting and polyurethane foam

| Property                              | Conventional cotton batting | Polyurethane foam | Cotton flote |
|---------------------------------------|-----------------------------|-------------------|--------------|
| Resilience                            | Fair                        | Too much          | Excellent    |
| Dimensional stability                 | Poor                        | Excellent         | Excellent    |
| Tensile strength                      | Poor                        | Excellent         | Excellent    |
| Moldability                           | None                        | Excellent         | Very good    |
| Moisture absorption                   | Excellent                   | None              | Very good    |
| Air permeability                      | Excellent                   | Poor              | Excellent    |
| Vibration damping                     | Excellent                   | Poor              | Excellent    |
| Performance at high relative humidity | Poor                        | Excellent         | Very good    |
| Oxidative damage resistance           | Excellent                   | Fair              | Excellent    |
| Temperature tolerance                 | Excellent                   | Fair              | Excellent    |
| Load bearing                          | Excellent                   | Fair              | Excellent    |
| Compression set                       | Fair                        | Excellent         | Very good    |
| High temperature-high load            | Very good                   | Fair              | Good         |
| Initial softness                      | Excellent                   | Good              | Good         |
| Resistance to weight loss in use      | Poor                        | Excellent         | Excellent    |
| Equivalent weight to do the job       | 1.0                         | 0.55              | 0.66         |

With the issuance of U. S. Patent 3,181,225 on May 4, 1965, the interest in the process increased tremendously. About this time General Motors Corp. followed Ford Motor Company in issuing specifications for the improved cotton batting.

Concurrently with these developments at least three other companies undertook the installation of production lines for the improved cotton batting product trade named "Cotton Flote." Within the next 6 months four additional companies announced that they would install the process in their plants. As of this writing, five companies are in some stages of commercial production of Cotton Flote, and some of this production is actually going into new automobiles. Meanwhile the research team has continued to try to improve product performance, to reduce the chemicals cost, to assist the companies piloting or installing the process to overcome many of the unexpected "bugs" encountered in upscaling, to assist the National Cotton Batting Institute to develop acceptable specifications for the manufacture and performance of the products.

For the small cotton batting manufacturer, we are trying to arrive at a means of pretreating the fibers to render the necessary capital investment within his means.

The National Cotton Batting Institute has recently placed full-page color advertis-

ing in Automobile Age, and plans to have additional publicity and advertising extolling the properties of Cotton Flote in both trade and consumer oriented magazines during 1966.

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### DISCUSSION

Question: Did I understand Mr. Knoepfler to give a percentage of the raw material that is required for this improved batting? Did he say how much less in weight it would take?

Mr. Knoepfler: What it amounts to is that the weight per unit in a cushion or a mattress pad or anything of that type is about one-third less than untreated cotton.

Now actually, what this one-third less in terms of weight does is help you in the

cost of the chemical processing. It reduces the cost of the finished material.

One thing that you might consider in this connection: Less weight will not result in a lower use of cotton batting. It will increase the use of cotton batting. We have already seen trends in this direction.

We are very happy to say that Ford and General Motors, on their recent statistics, show that the use of cotton batting has now gone up to about 25 pounds per car per year. When you are talking in terms of nine million cars per year, this is a tidy little amount of cotton batting to be used per year.

## **INACTIVATION AND REMOVAL OF AFLATOXIN**

[Summary]

by

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(Presented in 2 parts by both authors)

The inactivation or removal of aflatoxins from oilseed products is one of the most challenging problems in our research program at the Southern Utilization Research and Development Division. As most, if not all, of you are aware, the aflatoxins may be produced by certain species of molds when conditions are suitable for their growth on oilseeds or other agricultural products commonly used for food or feed. Their extreme toxicity, of the order of micrograms for some species of animals, has made necessary the use of aflatoxin analyses for quality control. Peanut meals containing more than 30 parts per billion of aflatoxins have been diverted to fertilizer markets at greatly reduced economic return, fertilizer grade meal bringing only \$20 to \$30 per ton. Thirty parts per billion would be equivalent to only 1.4 milligrams in a 100-pound sack of meal. This 1.4 milligrams is a very small quantity, but it could produce a positive test in 700 day-old ducklings. As you can readily visualize, the removal of this small quantity of material dispersed in 100 pounds of meal poses a real problem.

The aflatoxin problem was first recognized over 5 years ago when toxic peanut meals were used for feeding turkeys in England. The peanut processors have done an excellent job of culling out undesirable peanuts from edible peanuts used for food. They have used physical separation, including electric eye sorting, and close analytical control. They were faced with, and still face, problems with lower-grade peanuts milled for oil and meal.

In our research to develop methods for removal or inactivation of the aflatoxins in contaminated peanut and cottonseed meals in which the Oilseed Crops and Engineering and Development Laboratories are cooperating, we are looking at the possibilities of helping all methods of processing using not only physical means, but also physicochemical or chemical, or both, means.

Effect of heat and moisture. --When our investigations were initiated at the Southern Division there were conflicting reports in the literature on the effects of heat on

aflatoxin in meals. One of our first undertakings was to determine the effect of time, temperature, and moisture content on the rates of destruction of aflatoxin in a cottonseed meal under conditions which might be achieved in a cooking operation. To carry out these cooking studies we used a small steam-jacketed stirred cooking vessel. A suitable charge of about 700 grams, about 1-1/2 pounds, of cottonseed meal were adjusted to the desired moisture content, placed in the vessel, brought up to temperature, and held for various periods of time. Heating cottonseed meal of 6.6 percent moisture content and containing 144 p. p. b. of aflatoxin B<sub>1</sub> at a temperature of 100°C. for from 1 to 2-1/2 hours reduced the aflatoxin to 108 p. p. b. Heating meal of 15 percent moisture content at 100°C. resulted in more rapid reduction in aflatoxin content to a level of 30 p. p. b. in 2-1/2 hours. Cooking at higher moisture contents did not produce very much greater reduction and lower temperatures were much less effective. Heat alone does not appear suitable for adequate destruction of aflatoxin since the curves of aflatoxin content versus time tend to level out before aflatoxin reaches acceptable levels. Furthermore, heating at 100°C. or higher temperatures for prolonged periods undoubtedly would result in some loss in nutritional value.

Evidence of aflatoxin destruction has been based largely on chemical assay using thin-layer chromatography and comparing intensity of the fluorescent spots with those of standards. Naturally, promising treatments must also be checked biologically and tests will be made to determine nutritional quality of the treated meals.

Chemical treatments that require heat and moisture to be effective can be carried out in the same cooker and the time-temperature-moisture data serve as a control to determine the advantage that the chemical is giving us in inactivation of the aflatoxins.

Chemical approaches. --Although most of you are not chemists, we would like nevertheless to present structures of the aflatoxin molecule in figure 1. Aflatoxin B<sub>1</sub> and G<sub>1</sub> are quite similar except on the right-hand side there is a different type of ring. You might look at this molecule as if you were looking at the floor plan of a 5-room house, each ring representing a different room. The walls of these rooms are well constructed, but there are points where one might be

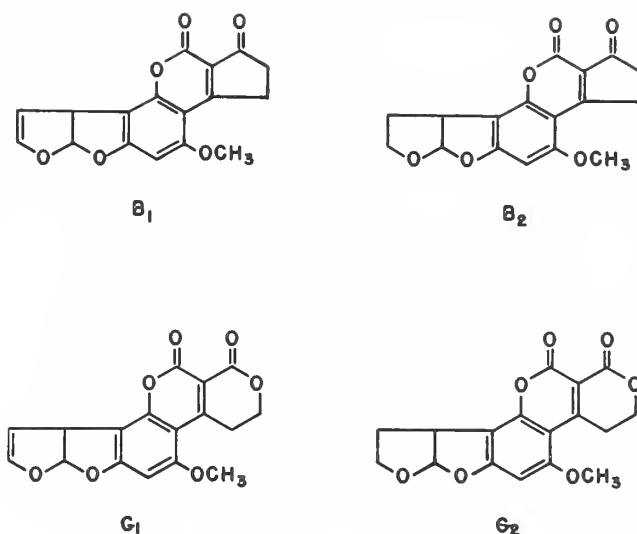


Figure 1.--Aflatoxin structures

able to open a door; that is, to open or disrupt a ring and reduce or eliminate the toxicity by changing the structure. The double bond in the ring to the left could be attacked by oxidizing agents. However, oxidizing agents can also alter other materials and are generally somewhat destructive in their action. The ether oxygens represent points of attack, but they are fairly resistant to chemical reagents. The weakest link is the group which is known as the lactone. Aflatoxins B<sub>1</sub> and B<sub>2</sub> have one lactone group, whereas aflatoxins G<sub>1</sub> and G<sub>2</sub> have two lactone groups. Lactones are esters and are susceptible to saponification or hydrolysis just as the ester group of cottonseed oil is susceptible to hydrolysis or saponification to form free fatty acids or soap, and glycerol. Reagents are being explored which would offer possibilities for opening the lactone ring. We are experimenting with basic reagents, alkalies and alkaline salts, and some of them appear to have promise of opening the door. Naturally, chemicals selected should be as nearly compatible as possible with feed products so that they themselves will not be deleterious or will not require extra treatment for their removal. Where possible, gaseous reagents are desirable since they more readily permeate throughout the mass than would reagents in solution.

Physical separation. --The peanut industry has made good progress through the

use of culling devices including photoelectric sorters, in the removal of contaminated peanuts from the bulk of the noninfected material.

For cottonseed several physical means of separation are under investigation. An example is segregation on the basis of density, ballistic or aerodynamic characteristics of the seed, and on other properties of the seed. For one lot of cottonseed, contaminated with between 40 and 80 p. p. b. of aflatoxin B<sub>1</sub>, a projection device concentrated over 63 percent of the aflatoxin in about 6 percent of the seed, and 85 percent of the aflatoxin in 25 percent of the seed. For another lot, contaminated with about 750 p. p. b. of aflatoxin B<sub>1</sub>, and using the same projection system, little or no segregation was achieved as most of the aflatoxin was in the sound seed.

Analyses of fractions of both aflatoxin-contaminated cottonseed and peanut meals separated by screening up through 200 mesh indicated that all fractions, coarse and fine, have essentially the same level of aflatoxin.

Extraction. --Research efforts have been directed to the use of solvent techniques to achieve a removal of 90 to 95 percent of the aflatoxin in oilseed material. They are (1) the simultaneous extraction of oil and aflatoxin from flaked meats or comminuted prepress cake with (a) 90 to 95 percent aqueous acetone or (b) a solvent mixture of acetone-hexane-water; (2) the extraction of aflatoxin from flaked oilseed meats with 70 percent aqueous acetone followed by oil extraction by any conventional means; and (3) the extraction of aflatoxin from oilseed meals, produced by conventional means, with either a mixture of acetone-hexane-water or by 90 to 95 percent aqueous acetone. Plans are underway to determine the effectiveness and practicality of such solvent techniques for use in existing solvent extraction plants with the minimum of necessary modifications.

Chemical treatment. --An approach which seems to offer promise of chemically reducing aflatoxin in oilseed meals is the treatment with ammonia, either anhydrous or as an hydroxide. Ammoniation with anhydrous ammonia under pressure reduces the

aflatoxin in both contaminated cottonseed and peanut meal up to 99 percent. The treatment conditions studied were 20 to 40 pounds per square inch gage, ammonia pressure, 7 to 15 percent moisture in the meal, and treatment times of from 15 to 60 minutes.

Indications are that the nutritive quality of ammoniated cottonseed and peanut meal (0.4 to 0.5 percent increase in nitrogen) is not appreciably reduced as determined by such chemical analyses as lysine (E. A. F.) and nitrogen solubility.

Ammoniation of comminuted peanut meats followed by conditioning and solvent extraction did not achieve reduction in aflatoxin comparable to reduction when the meals were ammoniated. Apparently, the oil masks or interferes with the effect of the ammonia.

The possibility of chemically treated meal as produced from both cottonseed and peanuts by all extraction methods and then held in storage for a period of time (hours) at a slightly elevated temperature is receiving attention as a practical means of inactivation of aflatoxin. Several chemical treatments offer possibilities.

In all the above investigations, attention is being directed to obtain practical means of deactivation, destruction, or removal of aflatoxin that are suitable for use in all extraction processes.

## DISCUSSION

Question: Does this aflatoxin problem seem to be more prevalent in any one section of the country opposed to another?

Mr. Dollear: It is my understanding that it certainly is not restricted to any one area.

As far as information we have, it could occur anywhere. It probably depends a lot on conditions under which seeds are grown, harvested, stored. In the case of peanuts, the curing operation is very significant.

Mr. Gardner says it could also vary from year to year.

## ADVANCES AND ADVANTAGES IN MISCELLA REFINING

by  
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Although solvent extraction of crude oil from cottonseed flakes has been a commercial process for the past 2 decades, continuous refining in the miscella state has only gained impetus in only the past 5 years. Theoretically, refining in a solvent medium should give higher yields of a quality oil than conventional procedures. However, to prove miscella refining practical, there had to be technological developments and economic change. Today, large size mills, year-around mill operation, the change in distribution patterns due to population movement and growth, better transportation facilities, the development of more sophisticated equipment have all helped to make miscella refining a reality.

There are two solvents used commercially today in miscella refining: Acetone as in the Vaccarino process developed and in use in Europe, and hexane as in the De Laval and Ranchers process, both in use in the United States and Mexico.

<sup>1</sup>/<sub>Planters Oil Mill.</sub>

The system and data to be presented here will be from the De Laval miscella refining process. This is a simple, easily controlled process for continuous treatment of crude miscella. A typical flow sheet for the De Laval process is shown in figure 1.

The crude miscella from the extractor is blended and controlled to the desired concentration in the feed tank for the system.

The crude miscella is pumped through a plate-heat exchanger, heated or cooled, whichever is required, to bring to desired processing temperature of 130° to 140° F. A Cuno strainer removes any meal and extraneous insoluble impurities. Passage through a flow measuring device automatically controls adjustment of reagent dosage, for any changes in feed flow to assure uniformity of operation.

The crude miscella enters the acid treatment section where acid, such as glacial

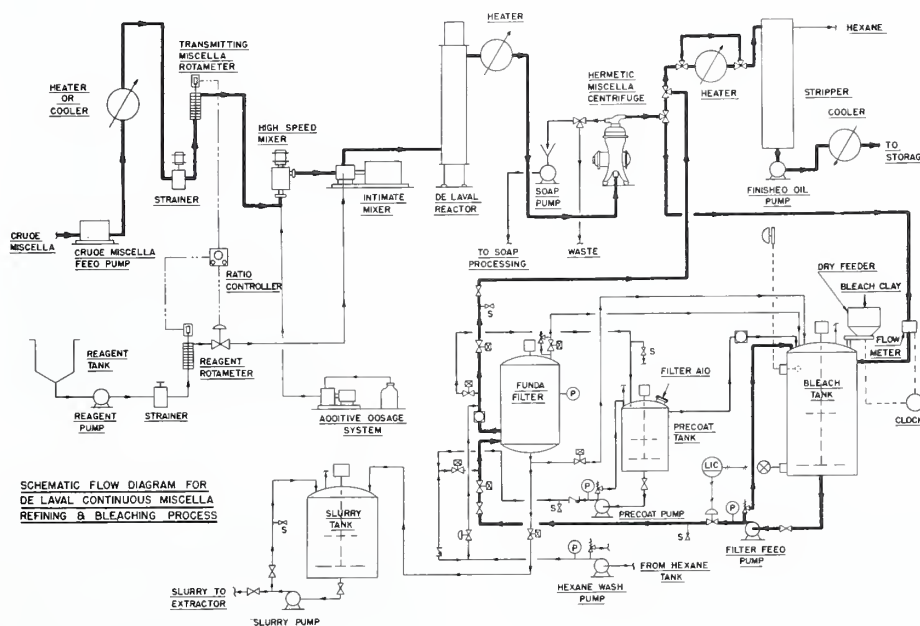


Figure 1.—De Laval Miscella Refining Process

acetic, is added in controlled parts per million quantity by a dosage metering pump, and the two are mixed. Immediately, the acid treated crude enters the reaction section, where caustic treatment added by a reagent pump chemically precipitates the impurities from the crude oil. The reaction mixture passes through a heater to bring temperature to desired range of 130° to 138° F. for separation. In a Hermetic centrifuge, the light yellow, neutral refined miscella is separated from the brown-black gummy fluid soapstock.

The refined miscella, dependent upon the individual mill operation, may be:

- (1) stripped of hexane, followed by polishing or bleaching treatment and filtration of the refined oil; or
- (2) continuously bleached and polish filtered in the miscella state, followed by stripping.

From the flow sheet and brief description of the mechanical equipment, certain advantages of miscella refining over conventional crude oil systems are quite evident.

- (1) This is a simple compact one-stage refining process.
- (2) The water-washing and vacuum-drying stages have been eliminated.
- (3) There is only a one-stage filtration for bleaching and polishing.
- (4) Due to low viscosity and specific gravity of the oil-hexane medium, there are both low heat loads and low power requirements.
- (5) Low operating costs.
- (6) Low maintenance costs.
- (7) Low initial investment.
- (8) The system is completely Hermetic, minimizing solvent loss and fire hazards.

A review of the chemistry of the process will reveal additional advantages. This process may be operated on: direct solvent extracted crude, a blend of prepressed oil with solvent extracted miscella from the cake, or a reconstituted blend of any source crude with hexane.

The oil-hexane ratio may be 45 to 67 percent Oil-33 to 55 percent hexane. Dependent upon the crude oil source, certain oil-hexane ranges appear preferable to others. Certain direct solvent extracted

crudes refine most efficiently at the 60 to 65 percent oil-35 to 40 percent hexane ratio. Reconstituted expeller oils refine best at 50-50 ratio.

The acid pretreatment dosage system permits processing of a wide range of crude oil quality. Acid treatment may be as low as 100 parts per million or as high as 1,800 parts per million. With offgrade crude oil miscella, the higher acid dosage ranges both improve bleached oil quality and reduce refining loss. It has been found that some types of crude oil may be caustic refined without acid dosage. However, in such a system, the high caustic requirements, the increased mixing and hold time, the high refining loss due to emulsification from neutral oil entrainment, the fringe refined and bleached oil colors of final oil, all make this procedure both uneconomical and impractical.

In the reaction section, the high-intensity, low-shear type mixer produces an extremely intimate contact between the caustic and the crude miscella. This fine dispersion of particles speeds the chemical reaction between the caustic and free fatty acid, phosphatides, and color bodies in the crude oil. The slow speed, paddle type mixers in the reaction section provide the 3 to 6 minute hold time required to complete the reaction. At the temperature range of 130° to 140° F., the chemical reactions proceed much more rapidly than at lower ranges. For example, only one-third the hold time may be required at 130° to 140° F., as at 100° F. Caustic concentrations may vary from as low as 12° B. to as high as 24° to 30° B. Generally, 16° to 22° B. caustic is used.

In separation, the difference in specific gravity and viscosity between the refined miscella and the soapstock, as well as the temperature range, 130° to 137° F., all permit excellent centrifugation conditions. This separation takes place in the hermetic-type centrifuge as shown in figure 2. This centrifuge has large discharge diameter for the soapstock phase, to accommodate the greater specific gravity differences between the miscella and soap phases.

Double seals, with a water barrier at the inlet, maintain cooler seals to avoid solvent loss and minimize operational hazards. A back pressure control on the refined miscella phase outlet maintains the separation zone at the proper location in the separator

bowl to assure light clear yellow refined miscella of less than 100 parts per million soap content. Usual value is 10 to 50 parts per million soap. The brown to black, gelatinous, free flowing soapstock phase is consistently low in hexane content, generally 3 percent or less.

The polishing filtration to remove the last traces of soap, or bleaching-polishing filtration process, is best accomplished on the refined miscella. The completely automated Funda Filter is the heart of this system (figure 3).

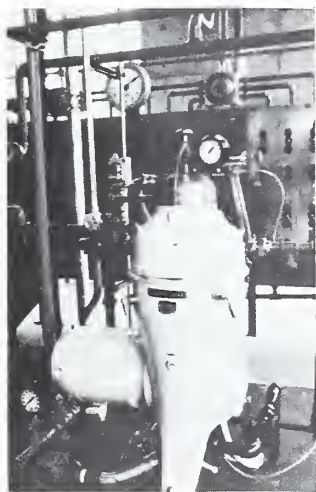


Figure 2.—De Laval Hermetic Centrifuge



Figure 3.—Funda Filter

This horizontal leaf-type filter is equipped with a rotating disc bundle and special type nozzles. The Funda automatically cycles itself through the precoat, filtration, draining, and cake washing stages. The

unit performs a displacement wash of the cake for maximum oil recovery and can be adapted to discharge either a wet or dry cake.

This type of filtration operation has many advantages, such as low operating labor costs, low maintenance costs, uniformity of operation, low oil loss in cake, readily disposable cake, and low bleach value finished product of very low soap content.

To demonstrate the flexibility of this miscella refining system, actual plant data on a wide range of crude oils from various sections of the country shall be given.

In table 1 is given data on direct solvent extracted crude cottonseed oils from the San Joaquin Valley of California and from West Texas.

A review of this data shows that a 1.0 to 1.5 percent FFA (free fatty acids) crude oil from California will have 3.3 to 3.7 percent theoretical loss, 5.8 to 6.7 percent AOCS cup loss. This type crude oil may be miscella refined with 31 to 37 percent oil savings over AOCS cup loss. Generally, West Texas crudes have a higher FFA content as shown, 1.5 to 1.9 percent, with theoretical loss in range of 3.5 to 4.5 percent, and considerably higher AOCS cup loss, 8.4 to 8.7 percent. In caustic miscella refining these West Texas crudes, the oil savings over cup loss are in the range of 39 to 43.5 percent.

It should be noted that generally the ratio of cup loss to theoretical loss is greater in West Texas crudes than in California. This may be attributed to the difference in the phosphatidic and gossypol content of these direct solvent extracted crude oils.

Both in AOCS cup refining and miscella refining, the finished refined oil may have a similar range of refined oil color. However, the bleach oil color of the miscella refined oil is always much lower than the cup color. Daily average over months of operation at a West Texas plant has consistently given bleach oil colors in the range of 0.9 to 1.2.

In direct solvent extraction processes, gossypol is extracted into the crude oil from the meal, and will give both a very dark colored miscella, and if stripped, a very dark colored oil. However, in stripping the crude oil, the color is set by degradation products of gossypol. These are difficult

Table 1. --Refined oil quality and loss in miscella refining direct solvent extracted crude cottonseed oil

| Seed source | Crude oil analyses |                  | AOCS cup results |                   |                  | Data on miscella refining |              |                   |                  |                                   |
|-------------|--------------------|------------------|------------------|-------------------|------------------|---------------------------|--------------|-------------------|------------------|-----------------------------------|
|             |                    |                  |                  |                   |                  | Plant loss                | Finished oil |                   |                  | Percent oil savings over cup loss |
|             | Per-cent FFA       | Theoretical loss | Loss             | Refined oil color | Bleach oil color |                           | Per-cent FFA | Refined oil color | Bleach oil color |                                   |
| California  | 1.0                | 3.3              | 5.8              | 6.3               | 2.1              | 4.0                       | 0.03         | 4.4               | 0.7              | 31                                |
| California  | 1.4                | 3.7              | 6.7              | 4.7               | 2.2              | 4.2                       | .02          | 5.0               | .8               | 37                                |
| Texas       | 1.9                | 4.5              | 8.4              | 4.0               | 1.8              | 5.1                       | .03          | 4.5               | 1.0              | 39.4                              |
| Texas       | 1.5                | 3.5              | 8.7              | 4.7               | 2.1              | 4.9                       | .02          | 4.1               | .9               | 43.5                              |

to remove in conventional refining procedures. In Miscella refining, the pretreatment of acid and caustic treatment at 130° to 140° F. removes the gossypol pigments. The presence of gossypol actually aids miscella refining by helping to compact the foots. This phenomenon had been observed as early as 1935 in processing cottonseed oil by the Skipin method. During Miscella refining of direct solvent extracted crudes, the actual conversion and removal of the gossypol pigment can be observed in the reaction mixture. The color of the refined oil gradually grows lighter in color as the pigment products are absorbed by contacting with the soap micelle.

Miscella refining is equally adaptable to prepress-solvent extracted crudes. In those plants, the miscella from the extraction of the cake with hexane is blended with the prepressed oil, generally in the ratio of 3 parts prepress to 1 part solvent oil.

Table 2 gives data obtained on the De Laval miscella refining systems in Mexico, where crudes are considerably offgrade by American standards. If this data is studied, it is noted that:

A finished oil product can be obtained, equal to or better than the AOCS bleach oil color at 34 to 38 percent oil savings over AOCS cup loss. This data was obtained on crude oils of 1 to 6 percent FFA content and 7 to 14 percent cup loss. Such a miscella refining operation appears almost miraculous, as feed to system is a jet black color, but refines in a 5-minute period to a light yellow colored edible product. One Mexican refinery consistently reports 30 to 40 percent oil savings over AOCS cup loss, with a bleach oil product in the range of 2.5 or less. Soap in finished oil averaged 3 to 7 parts per million.

These same crude expeller-solvent extracted oils, when conventionally refined, are usually caustic treated, then re-refined, followed by water-washing and vacuum-drying. In such a 4-stage process, if a finished oil equal to the cup quality can be obtained with 5 to 10 percent oil savings over cup loss, it is considered excellent. To accomplish this feat requires a really experienced operator. Most generally, losses exceed cup values.

The profitability of miscella refining becomes even more apparent when poor grade

Table 2. --Refined oil quality and loss in miscella refining prepress solvent-extracted crude cottonseed oil

| Seed source | Crude oil analyses |                  | AOCS cup results |                   |                  | Data on miscella refining |              |                   |                  |                                   |
|-------------|--------------------|------------------|------------------|-------------------|------------------|---------------------------|--------------|-------------------|------------------|-----------------------------------|
|             |                    |                  |                  |                   |                  | Plant loss                | Finished oil |                   |                  | Percent oil savings over cup loss |
|             | Per-cent FFA       | Theoretical loss | Loss             | Refined oil color | Bleach oil color |                           | Per-cent FFA | Refined oil color | Bleach oil color |                                   |
| Mexico      | 5.7                | 9.3              | 13.5             | 11.7              | 2.9              | 8.8                       | 0.03         | 8.2               | 2.9              | 35                                |
| Mexico      | 6.0                | 7.6              | 14.0             | 9.7               | 3.0              | 9.3                       | .03          | 8.1               | 2.9              | 33.6                              |
| Mexico      | 1.1                | 3.3              | 7.1              | 4.6               | 2.1              | 4.4                       | .03          | 4.7               | 2.4              | 38                                |

crudes are reconstituted with hexane and miscella refined. Table 3 gives some basic data on an offgrade expeller crude.

been in the past decade. The acid water fraction of a pH 3.0 may be neutralized with caustic and sent to sewer. Studies are

Table 3. --Refined oil quality and loss in miscella refining reconstituted expeller oil [50 percent oil:50 percent hexane]

| Crude oil analyses<br>Percent Theoretical<br>FFA      loss |     | AOCS cup results |                         |                        | Data on miscella refining |                |                         |                        |                                              |
|------------------------------------------------------------|-----|------------------|-------------------------|------------------------|---------------------------|----------------|-------------------------|------------------------|----------------------------------------------|
|                                                            |     | Loss             | Refined<br>oil<br>color | Bleach<br>oil<br>color | Plant<br>loss             | Finished oil   |                         |                        | Percent<br>oil sav-<br>ings over<br>cup loss |
|                                                            |     |                  |                         |                        |                           | Percent<br>FFA | Refined<br>oil<br>color | Bleach<br>oil<br>color |                                              |
| 1.8                                                        | 3.5 | 6.1              | 10.3                    | 4.8                    | 3.9                       | 0.03           | 7.3                     | 4.3                    | 36                                           |
| 1.8                                                        | 3.5 | 6.1              | 10.3                    | 4.8                    | 4.45                      | .03            | 4.9                     | 2.5                    | 27                                           |

It should be noted that this expeller oil, even in AOCS refining, gave a final bleached oil color considerably in excess of cottonseed oil trading rules; for example, refined oil color of 10.3 and bleach oil color of 4.8. However, this crude could be miscella refined to a bleach color of 4.3 with 36 percent oil savings over cup, and bleach color or 2.5 with 27 percent oil savings over cup. Such values have been realized in plant operation. In these crudes, the ratio of refined to bleach color is 2-1. This is the result of both a different family of color bodies present in the crude oil, as well as the effect of high temperature reaction products.

Miscella refining can also be used advantageously in processing such oils, as soybean, safflower, wheat germ, and even lanolin. However, it has been exploited first by the cottonseed mill operators because the competitive market has demanded progressive action.

The byproduct soap of cottonseed oil miscella refining is also of value. Presently, both direct extraction and prepress-solvent operators are pumping the fluid soap from the refinery directly over to the desolventizer-toaster unit in the extractor. Thus, there is no loss of hexane. The addition of the soap to the spent flakes generally increases the fat content of the meal by about 0.9 percent. The soapstock addition also increases meal weight, the ratio of soluble nitrogen to total nitrogen value, and decreases free gossypol content. The treated meal is easier to handle, and to pelletize.

The miscella soap may also be continuously acidulated to recover the fatty acid fraction as an acid oil. The market for acid oils is far more favorable today than it has

currently being made on the waste acid water, to recover any useable fraction, and to minimize or eliminate any pollution problem.

The advances made in Miscella refining technique is a direct result of the many advantages of the process. There is flexibility of treatment for a wide range of crude cottonseed oils, to give far higher yields than possible by more conventional procedures. Even the poorest grade crudes can be consistently refined at 30 to 40 percent oil savings over cup. Finished oil may easily equal AOCS cup bleach color, and can consistently be in range of 1.2 or lower on certain source crudes. The byproduct soap adds value to the meal when it is added back to the Desolventizer-Toaster. Acidulation of the soap will produce a marketable acid oil.

From the foregoing, I hope you will agree that the advantages initially inherent in miscella refining have been enhanced by the advances in its technique.

## DISCUSSION

Question: I wonder if the introduction of the soapstock to the meal stream results in an increase in the gossypol content of the meal.

Mrs. Crauer: I know that it does not increase the free gossypol content. Typical data on direct-solvent cottonseed meal, with soapstock added, is 0.137 free gossypol, 0.66 percent total gossypol. Perhaps Pete Reeves could also answer that question.

Mr. Reeves: We haven't found any variation to amount to anything in the total gossypol increase in the meal. In other words, we figure there is quite a saving in being able

to pump the soapstock into the meal and also make a high quality meal, resulting in higher fat and food value to the livestock.

Mrs. Crauer: Thank you very much, Mr. Reeves. Does that answer your question?

Questioner: Yes.

## THE COMPETITIVE POTENTIAL OF COTTONSEED OIL AS AN INDUSTRIAL RAW MATERIAL

by  
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Cincinnati, Ohio

From time to time various companies have evaluated cottonseed oil as a potential raw material for the manufacture of industrial chemicals. One or more individuals within the organizational framework of a company must make the decision as to whether cottonseed oil should be preferred to other available raw materials which will yield the same chemicals. I would like to assume the position of an individual in a fictitious company and go through the exercise of determining whether cottonseed oil should be used to manufacture a group of fatty acid products. In this exercise I will not consider every detail, but only discuss in a general way those pertinent points which will support a sound decision.

First of all, it is necessary to define the type of company for which this decision must be made. This company manufactures a full line of fatty acids, is capable of synthesizing derivatives of these acids, can chemically convert these acids into other chemicals, and can produce products for both the edible and inedible markets. Its manufacturing facilities include fractionating stills, pressure splitters, distillation columns, solvent crystallization units, chemical reactors, and converters. It has no captive raw materials and, therefore, must purchase its raw materials in the commodity market.

It is obvious that I have included in this definition all manufacturers of fatty acids in the United States which comprise the Fatty Acid Industry.

To reach a sound decision as to whether cottonseed oil would be the preferred raw material, the following points must be considered:

- (1) Variations in quality of cottonseed oil.

- (2) Availability of cottonseed oil.
- (3) Fatty acids which can be derived from cottonseed oil.
- (4) Competitive raw materials which will yield similar products.
- (5) End-use applications for cottonseed oil fatty acids.
- (6) Economics of using cottonseed oil in preference to other raw materials.

Since fatty acids can be derived from either whole oil or cottonseed soapstock, variations in both raw materials must be considered.

Generally speaking, cottonseed oil extracted from the cottonseed by any one method of processing will be uniform in quality. However, there are variations in the quality of the fatty acids produced from cottonseed oil when comparing one method of extraction with another. Therefore, depending upon how the oil was recovered from the seed, it is necessary to modify the method of manufacturing fatty acids to realize uniform quality in the finished product.

This quality difference carries over into the fatty acids produced from cottonseed soapstock. Throughout the years there have been greater differences in the quality of soapstock obtained from the various sources than in whole oil. Within the past 2 years the quality has become significantly poorer not only because of the shorter time interval between the time when the seed is harvested and when the oil is extracted but also because of improvements realized in the refining of the oil. In past years the "oxy acid" content would vary between 2 and 3 percent, but in recent years this type of raw material has become rare.

So, in reaching a decision regarding cottonseed oil and soapstock as a raw material for the manufacture of industrial chemicals,

these variations in quality must be considered as being somewhat undesirable. The result of these variations is higher manufacturing cost and the necessity of process research to determine how the various qualities can be effectively handled in any plant.

The availability of cottonseed oil and cottonseed soapstock must be investigated to ascertain a continuous supply of this raw material.

Historically, over the years cottonseed oil production has been fairly steady with year to year variations resulting from adverse climatic conditions, modifications in the government cotton program, export demands, domestic demands as related to other edible oils, and the actual yield of oil per ton of seed crushed.

It is predicted that in the 1965-66 marketing year there will be a decline in the availability of cottonseed oil production, primarily due to lower oil yields and increased domestic use. This will definitely affect the use of cottonseed oil for the manufacture of industrial chemicals primarily on the basis of economics which will be discussed later.

Presently many sources are predicting a cutback in the government cotton program for 1966 which will further deplete the availability of cottonseed oil. Likewise, soapstock will be similarly affected, but since it is a byproduct in the processing of cottonseed oil and large volumes are used in animal feeds which must be competitively priced with tallow, the price of soapstock will not be as adversely effected.

In making the decision as to the feasibility of cottonseed oil for the manufacture of industrial chemicals, it is important to know the types of fatty acids which can be manufactured from this raw material.

Below I have described the products which can be manufactured and in table 1 have tabulated the fatty acid composition of these products.

- (A) Hydrolyzing cottonseed oil or soapstock, separating the glycerine from the fatty acids, and then distilling the fatty acid yield a product normally referred to as whole cottonseed fatty acids.

- (B) Partial hydrogenation of cottonseed fatty acids followed by distillation yields a product low in polyunsaturated acids and having improved oxidative stability.
- (C) Complete hydrogenation of cottonseed fatty acids followed by distillation yields a saturated acid having a reasonably high stearic acid content.
- (D) Fractionation of Product A by means of a solvent fractional crystallization process yields a saturated fatty acid fraction high in palmitic acid.
- (E) Fractionation of Product A by means of a solvent fractional crystallization process yields an unsaturated fatty acid fraction high in linoleic acid.
- (F) Complete hydrogenation of Product D followed by distillation yields a completely saturated palmitic acid product.
- (G) Complete hydrogenation of product E followed by distillation yields a saturated acid very high in stearic acid.
- (H) Fractionation of Product A through fractional distillation yields a saturated acid fraction closely resembling Product D.
- (I) Fractionation of Product A through fractional distillation yields an unsaturated acid fraction similar to Product E.
- (J) Complete hydrogenation of Product H followed by distillation yields a saturated palmitic acid similar to Product F.
- (K) Complete hydrogenation of Product I followed by distillation yields a product similar to Product G.

It is apparent from table 1 that various types of fatty acids and derivatives can be obtained from cottonseed oil ranging from highly polyunsaturated to highly saturated products. They can readily fulfill those end-use applications where vegetable-derived fatty acids are required. They also can be utilized for both edible and inedible purposes. This wide range of products which can be produced from cottonseed oil would be considered an advantage to its utilization as a basic raw material and, therefore, would be weighed as a positive factor in reaching a decision.

Other raw materials are readily available which will yield fatty acids similar to those derived from cottonseed oil.

Table 1. -- Fatty acid composition

| Product | Composition     |                 |                   |                 |                   |                   |                   |
|---------|-----------------|-----------------|-------------------|-----------------|-------------------|-------------------|-------------------|
|         | C <sub>14</sub> | C <sub>16</sub> | C <sub>16:1</sub> | C <sub>18</sub> | C <sub>18:1</sub> | C <sub>18:2</sub> | C <sub>18:3</sub> |
| A       | 1.0             | 26.0            | 1.0               | 3.0             | 17.5              | 51.0              | 0.5               |
| B       | 1.0             | 26.0            | 1.0               | 29.0            | 42.0              | 1.0               | ---               |
| C       | 1.0             | 27.0            | ---               | 71.0            | 1.0               | ---               | ---               |
| D       | 0.5             | 84.0            | 1.0               | 9.0             | 2.5               | 3.0               | ---               |
| E       | 0.5             | 4.0             | 0.5               | ---             | 24.0              | 70.0              | 1.0               |
| F       | 0.5             | 85.0            | ---               | 13.5            | 1.0               | ---               | ---               |
| G       | 0.5             | 4.5             | ---               | 94.0            | 1.0               | ---               | ---               |
| H       | 1.5             | 90.0            | 1.5               | 0.5             | 2.5               | 4.0               | ---               |
| I       | ---             | 5.0             | ---               | 4.0             | 23.0              | 67.0              | 1.0               |
| J       | 1.5             | 91.5            | ---               | 6.0             | 1.0               | ---               | ---               |
| K       | ---             | 5.0             | ---               | 94.0            | 1.0               | ---               | ---               |

There are a number of fats and oils available having the same type of fatty acids that are present in cottonseed oil, but in varying amounts. This is illustrated in table 2 where it is shown that tallow contains an

The composition of competitive raw materials shown in table 2 can be compared with the composition of products given in table 1 to determine whether cottonseed oil is unique for the manufacture of industrial chemicals.

Table 2. -- Fatty acids in some common oil raw materials

| Material       | Composition     |                 |                   |                 |                   |                   |                   |
|----------------|-----------------|-----------------|-------------------|-----------------|-------------------|-------------------|-------------------|
|                | C <sub>14</sub> | C <sub>16</sub> | C <sub>16:1</sub> | C <sub>18</sub> | C <sub>18:1</sub> | C <sub>18:2</sub> | C <sub>18:3</sub> |
| Corn Oil       | ---             | 12.5            | ---               | 2.5             | 29.0              | 55.0              | 0.5               |
| Cottonseed Oil | 1.0             | 26.0            | 1.0               | 3.0             | 17.5              | 51.0              | 0.3               |
| Palm Oil       | 1.5             | 42.0            | ---               | 4.0             | 43.0              | 9.5               | ---               |
| Safflower Oil  | ---             | 8.0             | ---               | 3.0             | 13.5              | 75.0              | 0.5               |
| Soybean Oil    | ---             | 11.5            | ---               | 4.0             | 24.5              | 53.0              | 7.0               |
| Sunflower Oil  | 0.5             | 7.0             | ---               | 5.0             | 19.5              | 67.5              | 0.5               |
| Tall Oil       | ---             | 1.0             | 0.5               | 1.5             | 50.0              | 46.0              | 1.0               |
| Tallow         | 3.0             | 26.0            | 5.0               | 20.0            | 42.0              | 3.0               | 1.0               |

equivalent amount of palmitic acid. Whether the fat or oil can be utilized for the manufacture of different fatty acids and derivatives depends upon the amount present and how readily it can be isolated from the other fatty acids.

When comparing one fat or oil with another, it must be remembered that it is not necessary to have exactly the same fatty acid composition to satisfy a particular end-use application. For example, in preparing calcium stearyl lactylate as a bread additive, the basic requirement is that the fatty acid must have a minimum stearic acid content of 87 percent. Therefore, a hydrogenated fatty acid derived from whole soybean oil fatty acids containing 88-91 percent stearic acid can be used just as well as Products G and K shown in table 1.

Product A, representing whole cottonseed fatty acids, has a palmitic to linoleic acid ratio of 1:2 and a palmitic to unsaturated acid ratio of 1:2.7. Since, as mentioned above, these acids can be used for both edible and inedible end-use applications it can then be compared with all competitive raw materials shown in table 2. None of the oils listed have this composition and could only be approximated by a 60-40 blend of safflower oil and palm oil if this were economically feasible. Therefore, cottonseed oil fatty acids are unique in this respect and would be considered an advantage provided this uniqueness can be exploited.

Products similar to B and C can be derived from edible or inedible tallow depending upon how they are to be used. However,

B and C would be preferred if they must be derived from a vegetable source.

Products D, F, H, and J which are high-content, palmitic acid materials could also be derived from palm oil or tallow by employing the same processing techniques. It is also obvious that Products E, G, I, and K can also be duplicated within reason by some of the oils listed in table 2.

Cottonseed fatty acids and palm oil fatty acids are the only two vegetable oils having high palmitic acid contents. Since cottonseed oil, as shown later, is more economically priced and is also a domestic oil, it could take preference over palm oil where the end-use application specified that the fatty acid be edible and from a vegetable source.

In reaching our decision we could claim an advantage for cottonseed oil regarding its unique palmitic to linoleic and palmitic to unsaturated acid ratio as well as its higher palmitic acid content.

In determining the usefulness of cottonseed oil as a raw material for the manufacture of industrial chemicals, there must be sufficient end-use applications to justify its use.

Table 3 lists a number of end-use applications where cottonseed fatty acids and derivatives can be utilized. Although this list comprises a number of uses where quality is not important, there are a significant number of areas where quality is important and cottonseed oil fatty acids or derivatives could find markets.

Table 3. --Products in which cottonseed fatty acids are used

|                         |                  |
|-------------------------|------------------|
| Agricultural Emulsions  | Lubricants       |
| Asphalt Additives       | Paint Dryers     |
| Carbon Paper            | Paper Coatings   |
| Caulking Compounds      | Pharmaceutical   |
| Cosmetic Emollients     | Pigment Wetting  |
| and Emulsifiers         | Agents           |
| Core Oils               | Plasticizers     |
| Detergents              | Printing Inks    |
| Epoxy Resins            | Rubber Emulsion  |
|                         | Polymerization   |
| Food Emulsifiers        | Soaps            |
| Hardwood Tempering Oils | Surfactants      |
| Latex Emulsions         | Synthetic Resins |

Cottonseed oil must be competitively priced with other readily available fats and oils to be utilized as a basic raw material.

In table 4 is listed the average yearly wholesale price for cottonseed oil and other raw materials listed in table 2. It is immediately apparent that this oil is competitive with palm, corn, and safflower oil, but is not competitive with soybean oil, tall oil, or tallow. If the predicted cutback in the government cotton program in 1966 becomes a reality, this oil might lose its competitive position relative to palm, corn, and safflower oils.

As mentioned earlier fatty acids and their derivatives can be manufactured from cottonseed soapstock. However, it is a by-product from the refining of crude cottonseed oil and, therefore, contains a number of constituents other than fatty acids and glycerides which must be removed by distillation. Keith (2) published an article on cottonseed soapstock in which he showed that distillation of acidulated soapstock yielded 21-28 percent residue. Taking this residue loss into account, soapstock which is currently listed at 7.5 cents per pound would yield a useful distillate costing 10.7 cents per pound. At this level it compares favorably with soybean oil and crude cottonseed oil itself, but not with tall oil and tallow. Since a large number of the end-use applications listed in table 3 can be satisfied by the tall oil and tallow the market for cottonseed oil fatty acids would be quite small. It is reported that higher quality alkyd formulations still require the use of cottonseed or soybean type fatty acids, but as further quality improvements are realized in the manufacture of tall oil fatty acids, this market will shrink.

## Summary

As an individual in the fictitious company described above, it would be my present decision not to recommend cottonseed oil as a basic raw material for the manufacture of chemicals. If the pricing of cottonseed oil became more favorable and the availability became more reliable, it would be worthwhile to reconsider this decision. Also it would be worthwhile to investigate on

a research basis the potential of palmitic acid and the unique ratio of palmitic acid to unsaturates and polyunsaturates, which is characteristic of cottonseed oil.

#### References

- (1) U. S. Fats and Oils, Statistical Bulletin 376, Economic Research Service, U. S. Department of Agriculture, Washington, D. C.
- (2) Keith, F. W., Blachly, F. E., Sadler, F. S., J. Am. Oil Chemists' Soc. 31, 298-302 (1954).

#### DISCUSSION

Question: I'd like to ask him a question. I wonder if it would be an ignorant question to

ask why it is that the cottonseed soapstock is priced higher than some of the other fats.

It looks as if the supply and demand would level it off, or are there some other uses that make it more valuable?

Mr. Zilch: This is true. I think that the answer to this is the fact that these soapstocks can be utilized in animal feeds, and therefore, it does give the manufacturer of soapstock an outlet.

If it weren't for these animal feeds, I would personally feel that the soapstock would be at a much lower price. Now maybe somebody else has some other ideas on this, but I think this is where it might be going.

## PROCESSING OF LOW-QUALITY COTTONSEED IN THE OIL MILL

by

W. Smith

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It is the feeling of the writer of this paper that anyone who accepts the responsibility of presenting a paper having to do with the subject assigned is, at least to some extent, presumptuous. If there is an expert on crushing low-quality cottonseed, one who has all the answers, the writer has yet to find him.

If the writer had been asked the question 10 years ago, "What is the best way to crush low-quality cottonseed?" it would not have been necessary to compose a paper on the subject and to take something like 20 minutes of your time to give an answer. His answer would have been, "As quickly as possible." This answer still has some merit, but conditions surrounding the oil-mill industry have changed to such an extent that blindly following such a procedure can get a mill into serious difficulty.

The usual condition that exists at an oil mill is that a substantial amount of fairly good cottonseed will be on hand, with a lesser amount of low-quality cottonseed on hand. However, there are instances when an oil mill is so unfortunate as to have all low-quality cottonseed. This poor fellow is really in trouble.

The term "low-quality cottonseed" is a relative one. It carries a different meaning from one section of the country to another. In some sections of the country, cottonseed having a 2 percent free fatty acid in the oil would be considered low-quality cottonseed. In other parts of the country, such as southern Louisiana and some portions of the Southeast, these would be considered good cottonseed. In these latter locations, cottonseed have been received having a free fatty acid in the oil of 25 percent and higher. Other factors that can contribute to cottonseed being of low quality are high moisture, high foreign material content, and various degrees of field damage. During the course of this paper, it will have to be remembered that "low quality" is a relative term.

One of the most important aspects of handling low-quality cottonseed through the mill is to know where they are in your storage houses. Some people make the mistake of scattering low-quality cottonseed about in different places in their storage houses, and consequently have no control at all over handling them. Under such conditions, they find it necessary to take the seed just as they come from the seed house. This means that

they may get a slug of low-quality cottonseed without warning at any time, which can cause a superintendent to lose control of his processing efficiency before knowing it. Whenever a mill has some good cottonseed and some low-quality cottonseed, it is extremely important that they be kept separate in order that control can be maintained when processing them.

As mentioned previously, there is some merit in crushing low-quality cottonseed as quickly as possible. The advantage of doing so is to get them crushed and out of the way without giving them the opportunity to deteriorate further. It is common knowledge that cottonseed high in free fatty acid get even higher at a very rapid rate. However, if by crushing these cottonseed quickly as they come into the mill you make products that cannot be sold at all, or can be sold only at a drastically reduced price, it is possible to suffer a great financial loss by following such a practice. Most marketing people will tell you that when you make an inferior product and reduce your price drastically to move it, there is a period at the beginning of the time during which prime products are made later when it is difficult to overcome the news that has been scattered abroad that Mr. John Doe's mill is crushing "hot seed." One of the products that gives the greatest difficulty in this connection is lint. In view of the changing conditions, in the second-cut lint market particularly, during the last year or so, it is the writer's firm belief that low-quality cottonseed should be blended with better cottonseed in order to make a product which is acceptable to the trade.

"Blending" strikes fear in the hearts of most superintendents and some managers. However, the writer is convinced that in order to do an acceptable job of oil milling in the future, an oil mill must be in a position to blend cottonseed and to do it mechanically. Blending by hand is somewhat better than not blending at all, but the mill will still be alternately slugged with good seed and bad seed. It is believed that most oil mills are going to have to adapt their seed bins to enable them to blend mechanically. An oil mill having a Muskogee type bin can partition off a suitable portion of the bin to enable it to use 1 compartment for low-quality seed and the other portion for good seed. This will permit mechanical proportional blending. It will probably be necessary to install some conveyor box with a discharge spout over the

portion of the bin containing low-quality seed, since most seed bins have a screw conveyor with no trough at all over the seed bins, or a screw conveyor in steel trough with the whole bottom of the trough cut out.

One of the characteristics of some low-quality cottonseed is that they will have long tags of lint attached to them. One of the greatest bottlenecks in an oil mill crushing such seed is the seed-cleaning room. Under these conditions, seed-cleaning equipment is going to have to receive greater attention than under normal circumstances. Depending upon the degree of such a condition, it may even be necessary to put on extra labor to keep the seed-cleaner screens from plugging up completely. Whatever it takes, however, it is worth the effort and cost rather than to follow the practice that has occurred in some quarters, which is to bypass the seed-cleaning equipment with all or a portion of the cottonseed. It may be necessary to increase the size of the perforations on the top seed-cleaner tray metal in order to get the seed through them. However, this is far more desirable than bypassing the cleaning equipment, because when this is done, you may expect torn up saws, fires, wrecked hullers, and so forth.

In connection with the top tray metal on the seed cleaner, it has been the writer's experience that it is helpful to replace the perforated metal with which the cleaner is originally equipped with perforated metal having a greater total open area but having the same size perforations. Most of you are familiar with the top tray seed-cleaner metal which is formed with depressed holes to give greater strength. This purpose is accomplished, but a very low percentage of open area is available. Sometimes replacing this metal with standard perforated metal may mean the difference between staying with perforated metal having smaller holes rather than going to the next larger size.

It has been the writer's experience that it is helpful to go to a herringbone metal on the bottom tray, having longer openings. This will allow the removal of more sticks than otherwise would be the case. Herringbone metal with 5/32 inch by 2 inches has been used successfully. A number of seed cleaners have metal with openings shorter than this, which may allow more long sticks to remain in the cottonseed.

The importance of properly clothing both trays of your seed cleaners to permit getting your tonnage through without bypassing any cottonseed and to permit maximum removal of sticks and other foreign material cannot be overemphasized. The proper blending of cottonseed will minimize the turmoil in your seed-cleaning room.

When the cottonseed reach the linter room, your troubles are not over. There are a number of little things that can be done that may not of themselves make a drastic improvement. However, when all these things are accumulated, a good, tight operator can show a great improvement. If keeping linters in good mechanical condition is important when processing good cottonseed, it is doubly important when processing low-quality seed. Very often, on low-quality seed which have been subjected to field damage, the seed coat, or hull, has deteriorated to such an extent that it is very easily broken apart. This means that the possibility of hulling in linters is greatly increased. During the past 2 seasons, it has been quite obvious to the writer, particularly in some areas, that more seed are being received from the cotton gins already hulled than in previous years. It has been attributed in some quarters to the increased use of mechanical harvesters, high-speed gins, and the emphasis on increased capacity on the old-style gins. All the writer can say is that it is a problem. In some areas, even on good seed large quantities of loose meats and hulls are present in the cottonseed. This is true to a greater extent in low-quality seed. If a mill is short on seed-cleaning capacity, this factor will certainly show up in the lint room.

To emphasize the seriousness of this problem, most operators recognize that a normal oil content of second-cut lint will run from 0.6 to 0.8 percent, but certainly not over 1 percent. During the current season, mills have been found to have oil in second-cut lint up to 3 percent, and several have been found running around 2 percent. A number of things can be done to minimize this problem. Linter adjustments may have to be varied, looser rolls may help where possible, the projection of the saw through the linter rib may have to be reduced, and the spacing between the float and the saw may have to be increased. Also, it may be necessary to mote heavily at the linter. All of these things just add up to operating your equipment properly. Sometimes this is the hardest thing of all to get accomplished.

It would be well at this point to emphasize the importance of mechanical condition of the linters; all of those things normally causing hulling in the linter on good seed cause even more hulling on bad seed. These include rough saws, bad ribs, worn and battered floats, rough rivet heads which fasten the density curve to the density-curve adjusting bar, density curves being pulled loose because of worn rivet heads, and so forth.

Saws being in good condition, free of broken places and burrs, is very important. Sidefiling on first cuts is a necessity, and on the very bad seed can be quite helpful even on second cuts and third cuts. Often-times, a good compromise is to sidefile the first cuts and to increase the schedule of sharpening second- and third-cut saws, touching them very lightly with the gummer in order to prevent making a burr. It may be necessary to sharpen second- and third-cut saws every 8 hours under such conditions.

Another thing that can be done is to install some 5/32-inch by 2-inch herringbone metal in the screw conveyors to permit the escaping of meats and trash. Normally, one would think that this would be most helpful between first-cut and second-cut linters and between second-cut and third-cut linters. However, if a mill is short on seed-cleaning capacity, it may also be helpful ahead of the first-cut linters. It has been mentioned at these clinics previously that it may be necessary some day for oil mills to go to cleaning the seed between the first-cut linters and the second-cut linters, as well as between the second-cut linters and the third-cut linters. This perforated metal in these conveyors accomplishes this in a small way. It is amazing to see the flood of meats and small trash that can be taken out of the seed in this manner.

It is also possible to install this same size perforated metal in rotor lifts. A better cleaning action is obtained in a rotor lift than in a conveyor, since it is possible to get a cleaning area of almost a full 360° on a rotor lift. If not properly done, it can create a cleanliness problem. It is believed, however, that a good oil-mill sheet-metal man could shroud this rotor lift so as to cause the material removed to be dropped into a conveyor carrying it to the separating room or into a container which could be carried to the separating room.

Another very effective way for obtaining removal of meats and foreign materials from cottonseed in the lint room is to install something like 5/32-inch by 3-1/8-inch wire on the seed chutes in front of the linters. A number of operators have done this and have obtained substantial improvement. Others have done it and only obtained modest improvement. Normally, when this is done and very little improvement has been made, it is because of the way the metal was installed. The wire should be installed in such a way that the seed and trash strike this wire first when they are pitched from the front of the linter. If the wire is installed in such a way that the seed and trash strike the metal portion of the chute and then slide over the wire, less benefit is obtained. In fact, a large part of the seed and trash will bounce into the seed conveyor without ever touching the wire. This will also create a cleanliness problem, but the material can be caught in pans in front of the linters, or a small screw conveyor can be installed in front of the linters into which this material may be dropped and conveyed away to the separating room.

There are several things that can be done on lint cleaning that can be helpful. Again, proper operation of equipment is most important. Normally, lint made from low-quality seed requires more beating than lint made from good seed. It may be necessary to increase the size of metal on the lint-cleaning equipment slightly. It may also be necessary to increase some speeds. It is usually a matter of judgment and playing with the size of metal and beater speeds in order to get it doing the best work possible. On very high acid cottonseed, screens have a greater tendency to blind over because of the gummy material associated with high free fatty acid cottonseed. This is even more pronounced on fiber beaters used in connection with the making of bran. In a number of mills, particularly on fiber beaters, it has been necessary to adapt the fiber beaters to enable a quick change of screens to be made. A spare screen is kept so that when the screen begins blinding over, it can be changed quickly. This problem is greatest on fiber beaters and pepper sections. It is not so pronounced on top passes and shale sections.

One way to alleviate the blinding of screens on fiber beaters and pepper sections is to tie pieces of 1/2-inch lace leather to the end of the spike and leave the ends long

enough to touch the screen. This is very effective. On beaters having cut-flight conveyors, it is quite helpful to bolt the pieces of leather belting to the flight so that they will wipe the screen. This is quite effective on preventing the blinding of the screen.

Going on to the hulling and separating room, proper operation of the equipment is again most important. On very high free fatty acid cottonseed, the gumminess associated therewith is again a problem. It will tend to blind huller-shaker screens, purifier screens, and hull-beater screens. Ro-balls, which are of much benefit on good cottonseed, can help alleviate this condition on bad seed. Some mills have installed ro-balls on their huller shakers, as well as on their purifier shakers. Hull-beater screens must be watched closely and cleaned religiously.

When crushing low-quality, high free fatty acid cottonseed, the press room is where grown men cry, lose all their hair, and hope that they will be able to retain their sanity. It is the writer's belief that free fatty acid in cottonseed is not the whole story, but that physical weather damage to the meat is also a factor. In general, however, it has been the writer's experience that extraction on mechanical presses will gradually suffer as free fatty acid increases up to 8 to 9 percent. As it increases beyond this point, the operator, for all practical purposes, loses complete control of his press room. This is not always the case, but it happens more times than not. Very often, the presses will not take the feed, they will foot excessively, the cages will blind over, the filter press cake will be a gooey mess, and so forth.

As far as the writer is concerned, blending of cottonseed in such cases is an absolute necessity. If possible, mechanical blending should be done in such a way as to hold the free fatty acid in the cottonseed going to the mill to about 5 percent. If all of the cottonseed at an oil mill runs 10 percent free fatty acid and higher, making it impossible to do much in the way of blending, the writer refers you again to what General Sherman had to say about war.

If a mill is blessed with a solvent extraction plant, it can usually do acceptable extraction on such cottonseed. If a mill still operates with hydraulic presses, its extraction will probably suffer, but it will probably still be able to maintain control. However,

if a mill is equipped with mechanical presses, then it has a tough way to go on very high free fatty acid cottonseed.

Very accurate mechanical blending is extremely important in the press room. For instance, on numerous occasions mills have been doing fairly satisfactory work on high free fatty acid cottonseed by blending down to something less than 10 percent, when a load of very high free fatty acid cottonseed would come into the mill, and for convenience these seed would be run right on into the mill. This results in the press room work falling to pieces, and it may be as much as a day or even longer before it can be straightened out again. In extreme cases, it may mean shutting down the press room, removing the cages, dismantling the cages, cleaning the bars, respacing them, and reinstalling the cages.

In connection with a gooey filter-press cake, the writer has been told by at least one operator that, when unable to make a good, dry filter-press cake, he solved his problem by precoating the filter press with a 100-pound sack of dry cottonseed meal.

On cooking, it has been the writer's experience that with very high free fatty acid cottonseed it is necessary to make some reduction in tonnage. A cooking time of about 75 to 90 minutes' range is usually necessary. Depending upon the moisture content of the seed, as much water as possible is added ahead of the rolls. Water is also added in the top of the cooker. However, it was found that the use of live steam in the top of the cooker on free fatty acid cottonseed was a mistake. Very light loads in the cooker rings were necessary with as much agitation as possible. The temperature of the meats entering the press was found to be very critical. Under the circumstances under which this study was made, a temperature of 250° to 255°F. was necessary. Any variance from this temperature caused extraction to suffer badly. It was found that this temperature was much more critical on high free fatty acid seed than on good seed. This temperature may vary from year to year and from mill to mill, but it is believed that, although the temperature for a given mill may vary, when the optimum temperature is found, it will be very critical.

In general, the cooking described above is not too different from the cooking of good

cottonseed. The major differences seem to be that a reduced tonnage is necessary, adding all possible water ahead of the cooker seems to be more important, live steam in the top cooker is out, low levels and good agitation are more important, and the discharge temperature is very critical.

In closing, the writer would like to say that he does not expect everyone to agree with everything in this paper. One of the comforting aspects of presenting a paper on oil-mill operation is that, while others may disagree with the one presenting the paper, they are never able to come out flatly and say, "You are wrong." There are too many variables, and each of these variables acts in too many different ways under different sets of circumstances. It is hoped, however, that not too many of you will make the comment with reference to the writer that was made towards one of the participants in the recent presidential election. The statement was made with reference to one of the participants that it wasn't so much that he didn't know what he was talking about, as it was that he just knew so much that wasn't true.

## DISCUSSION

Question: I'd like to ask Mr. Smith if he would give us a range of perforation sizes that he would recommend on rotor lifts and conveyor troughs for removal of meats and trash and so forth.

Mr. Smith: What we have used normally is 5/32 by 2 inches. Now, it will vary from one part of the country to the other because in some parts of the country the seed are larger and you may have to adjust them a little bit.

The main thing is to get the perforation size so that just the trash and meats and perhaps a few immature seeds will be kicked out.

# COOLING COTTONSEED AT MINIMUM COST

by  
M. C. Verdery  
Anderson, Clayton & Co.  
Houston, Tex.

During the past 3 or 4 years there has been more good technical information developed on seed cooling and more intelligent interest stimulated among oil millers than in all of the 40 or so years that cottonseed have been aerated by pulling or blowing air through them.

Until 3 or 4 years ago I doubt that one superintendent out of 10 could tell you:

- (1) Static pressure on his cooling system.
- (2) Total volume of air handled by each fan or the cubic foot of air per ton of seed stored.
- (3) Velocity of air and pressure drop in main ducts.
- (4) Horsepower requirements of the cooling fans.

W. B. Harris,<sup>1/</sup> F. W. Rabe,<sup>2/</sup> and others have questioned some of our old inefficient practices. Several of our superintendents have experimented and tried new procedures and we now know that:

- (1) Somewhere between 2 cubic feet per minute and 3 cubic feet per minute of air per ton of seed stored is required for efficient cooling, depending on the type and condition of seed and the local climatic conditions.
- (2) A high static fan on a seed house is an indication of improperly designed cooling systems or poor fan selection.
- (3) Adequate sized ducts, proper fan selection, and well-designed laterals properly arranged, will result in maximum volume of air passing uniformly through the seed at minimum power requirements.

During the past year we have heard a lot of talk about "entrance area" and "entrance velocity" in connection with cooling cottonseed. I now believe this is one of the most important, and perhaps the least understood,

things about cooling systems. This has been stressed and explained by Harris and Rabe but I doubt that many of us have checked our own installations and observed the considerable difference between installations.

What is "entrance area?" It is the effective, open area along side floor laterals through which the air may pass into the lateral from the seed. For example, if a lateral is blocked up 4 inches above the floor, we have an effective opening of 0.66 square feet for each linear foot of lateral. For 20-foot long laterals we would have 13.2-square-foot entrance area. If in a 100' by 250-foot seed house we have the equivalent of 100 20-foot laterals, we would have a total entrance area of 13.2 times 100 or 1,320 square feet. Dividing 20,000 cubic feet per minute of air handled by this system by the 1,320-square-foot entrance area, we arrive at an entrance velocity of 15 feet per minute.

If the laterals mentioned in the above paragraph were blocked up 6 inches instead of 4 inches, or by using a lateral, we obtain an entrance area of 1 square foot per linear foot of lateral or 20 square feet per lateral. In the above mentioned seed house, with 100 laterals, we would then have a total entrance area of 2,000 square feet and an entrance velocity of 10 feet per minute. This should result in still lower pressure drop and less total static on the system.

We feel very strongly that with a properly designed system, and with adequate entrance area into the laterals, there should be no problem in operating at a total static on the fans of 6 inches to 8 inches and handling maximum volumes of air for minimum power. We might stress again that in areas that frequently receive extremely high moisture seed, it would be necessary to design the system to handle a larger volume of air per ton of seed, say up to 4 cubic feet per minute in extreme cases. Naturally, the entrance area to the floor laterals would

<sup>1/</sup> Harris, W. B., "Cottonseed Cooling," Cottonseed Products Research Laboratory, February 1961.

<sup>2/</sup> Rabe, W. F., "Aeration of Cottonseed," Oil Mill Gazetteer, June 1965.

have to be twice as great as it would for a more conventional installation handling 2 cubic feet per minute or else twice as many laterals would have to be used.

Although we still feel very strongly that better and more uniform seed cooling results will be obtained where the air is pulled toward the center of the pile, we would like to point out that under some conditions this is difficult, if not impossible, with the so-called Johnson system of pulling all of the air to the tunnel. If we consider the Johnson system as applied to a 100' by 250-foot Muskogee seed house, we would naturally prefer to keep the tunnel completely closed for at least 40 feet from each end of the house to avoid short circuiting. This would leave us the openings on both sides of the tunnel for a distance of 170 feet and result in an effective entrance area of 680 square feet. This would not amount to more than one-half or one-third of a well designed system with proper floor laterals. This seed house would hold about 11,000 tons of seed. At 2 cubic feet per minute per ton of seed, we would normally handle about 22,000 cubic feet per minute which would give us an entrance velocity of 32.4 feet per minute which is definitely on the high side. The situation is even worse in trying to pull through the tunnel of a 150' by 160 foot Muskogee house. The entrance area would be cut approximately in half and the entrance velocity doubled. It is therefore obvious that on any of the tunnel cooling systems, the tunnel openings must be supplemented with floor laterals and/or an expanded covering or cage around a portion of the tunnel where the air enters.

We might explain that on one installation of a 150-foot by 160-foot Muskogee seed house with a capacity of 13,000 tons of cottonseed, we had installed a Johnson system pulling all of the air through the tunnel. Six 30-foot long auxiliary laterals had fortunately been installed in the corners and along each side for supplemental protection. With two 60-inch Fort Worth standard fans, each equipped with 50 horsepower motor, we had hoped to operate the system at 6 inches or 8 inches total static and handle about 18,000 cubic feet per minute per fan. Unfortunately, we had failed to calculate the entrance area into the tunnel and the air ducts. A check soon revealed that the entrance velocity would have been well in excess of 85 feet per minute had the system been operated as

anticipated. This excessive entrance velocity had increased the static pressure on the system to 15 inches and under these conditions we estimated the volume of air from each fan at approximately 9,000 cubic feet per minute, just about half what we expected and what we hope to get when adequate entrance area is provided. Even with the reduced air volume we estimated entrance velocity at 43 feet per minute, which was probably responsible for increasing total static by 5 inches or 6 inches water gauge.

You will note from the sketch we are circulating that by expanding the cross section of the tunnel and covering this outer surface with expanded material we anticipate an inlet area in a 60 foot length of tunnel of approximately 1,200 square feet. By adding special floor laterals we anticipate picking up another 1,500 square feet of entrance area, which will give us an entrance velocity of 13 feet per minute. We believe that this will make it possible to operate the system at something like 6 inches to 8 inches total static and handle a total of 36,000 cubic feet per minute. Slightly higher statics may be required on 150' wide houses.

In conclusion, we urge that all of you check the entrance area and entrance velocity of your seed cooling systems. Where the velocities range from 10 feet per minute to 20 feet per minute you have nothing to worry about, although you may not be handling enough total volume of air. Where the velocities approach or exceed 40 feet per minute, you have a good opportunity to make a substantial reduction in static by providing more entrance area or more laterals.

## DISCUSSION

Mr. M. C. Verdery: If anybody has any questions about what I mean by entrance area or how to get more entrance area, I will be glad to try to answer it.

Question: I'd like to ask Mr. Verdery how he keeps those laterals in place in a seed house. Every year so far when I go into some of the large 150-foot-wide houses with 16-foot walls, a lot of the laterals are pushed clear back against the wall. If I anchor them down with big bolts, when I go in there to bring the seed out, I will tear up the scoop or the laterals, and I was just wondering what was the best way to go about it.

Mr. Verdery: Most of our mills secure some blocks to the floor to keep them from sliding or insert studs in underside of lateral to fit holes drilled in floor.

Some of the mills claim they can hold them by simply covering them with seed, in other words, putting a foot or two of seed over the laterals.

This also prevents accumulation of lint over these laterals. I think laterals should be secured in place by having a block bolted to the floor on either side of it to keep it from slipping.

Now, one other arrangement - and this might be helpful - in several places where we have been blocking up laterals to get more entrance area, rather than just putting some four by sixes under one lateral, and where the laterals are spaced on 5-foot centers, we will extend those four by sixes to take two laterals.

Then you secure the lateral down to the four by six. This ties two of them together giving a more rigid assembly that doesn't slide around as badly.

Question: Well, I tried that, but it won't work. And I will tell you the reason why, because those big scoop tractors, which everybody, I guess, is familiar with in their mills, will go in and get those two by fours and four by sixes and they will wind up in either the elevator or the screw conveyor, and they will cause more mechanical difficulties that way.

So personally, I have gotten away from wood. I don't have any wood. I take 20-inch pipe and split it and put 4-inch blocks under that to raise it up off the floor, and still they slide around. If you bolt them down, they are sure going to tear up the tractor when they hit that thing. You can tell them and threaten to fire them and everything else, but that doesn't do any good.

Mr. Verdery: Well, I agree with you, the steel is better provided you have sufficient entrance area, but it sounds like you have already answered your own question.

Everybody has their own ideas and there are several solutions.

Question: This is a different question. Have you any idea of your average cost per ton of cooling cottonseed?

Mr. Verdery: You mean the power cost?

Question: Yes.

Mr. Verdery: Oh, I'd say it can run anywhere from 5 cents to 20 cents per ton of seed. This is just a round figure. And naturally, in any kind of an oil mill operation, the main thing we are interested in is how much is it going to cost and how much profit is it going to make for the company.

We don't want to be putting in a low static system just because we like it. We hope it's going to make us some money. The cost will depend on how many hours you have to fan, and that depends on the moisture in the seed and the temperature conditions and how long you have to store the seed.

It can vary quite a bit. I'd say a round figure though, on power cost, would range anywhere from 5 cents to 20 cents, and it could be more.

Have you any figures on that, Walton?

Mr. Smith: I have them, but they are at the office and I can't remember them.

Mr. Verdery: You don't have them in the back of your head?

Mr. Smith: No sir, I sure haven't.

Mr. Verdery: Well, frankly, I believe if we get the most efficient system in the world, it isn't going to make us rich, but as the old saying goes, every nickel counts, and if we can save a dime a ton, we are doing all right, and then we will try to save another one.

Before you do any of these things that have been recommended, I am sure you are going to put the pencil to it.

To get back to this business of the floor laterals sliding around, have you had any problem there Easley? What do you do about it? Mr. Easley said he has a very rough finish on his concrete floors and they don't slide quite as bad.

Anybody else have any comments on that? How about you, Allen?

Mr. Allen Smith: I don't have a slide rule, but I can give you the figures here.

Mr. Verdery: Well, I'm talking about trouble with laterals sliding around.

Mr. Allen Smith: Mr. Charlie, do you have any trouble?

Mr. Charlie Caldwell: The only trouble I generally have is, if you are putting your seed on one side, it might push the lateral out of position.

Mr. Verdery: Oh, you have them do some covering before the seed falls on them, is that right?

Mr. Caldwell: That's right.

Mr. Verdery: And that, of course, prevents a lot of loose lint getting on them, which is a good idea.

Question: In the exhaust from your fans, you have a large volume of low pressure compressed air coming out. Can you do anything to recover that power?

Mr. Verdery: Not that I know of.

Question: Is there any distinct advantage to this corrugated perforated metal lateral over a wooden lateral?

Mr. Verdery: I am glad you brought that up. I have always been a strong advocate of the wooden lateral blocked up six inches on the overhanging sides and notches on the upper side of the vertical piece, which is shown on my sketch there.

I feel that gives you a good 6 inches. Now, this idea for the perforated corrugated lateral is something that is used extensively by the grain and soybean people, and Mr. Rabe, who is an authority on cooling of grains and has made one or two talks at our cottonseed meetings, swears that it will give us more entrance area and it will get the job done.

I haven't tried it, so I can't guarantee it, but I am going to try a few of them as soon as I can get around to it, perforated corrugated. He says you will get the benefit of the full surface of that lateral.

Question: In other words, you get the benefit of the perforation in the pipe plus blocking up 6 inches?

Mr. Verdery: He says after it goes through the perforations, it can then spread all under the seed and you get the benefit of the complete area.

I am glad you brought it up though. It is something I have not tried, and I am taking Mr. Rabe's word for it. It sounds reasonable.

Question: I'd like some more discussion on the cost of fan hours of cooling seed, because according to my calculations, our cooling costs a lot more than you said.

Mr. Verdery: That just depends on how long you store the seed, that's right, it could very well be.

## WHAT IS AN IMPROVED COTTONSEED MEAL WORTH?

by  
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For some time there has been no limitation on the use of cottonseed meal in the rations of ruminants. There also is little need for improving them for this use. In discussing

what an improved cottonseed meal might be worth, it is necessary to look to the monogastric or simple-stomached animal as the user because it could make use of such an

improved product. Swine and poultry then hold the key to the success of improved cottonseed meals. This paper will deal with the poultry side of the question although the comments will apply equally to the swine industry.

Before entering into a discussion of what improved cottonseed meals would be worth in the poultry industry, an analysis of the cost factors in the industry would be appropriate. At the present time a 3.5-pound broiler is worth 14 cents per pound at the farm or 49 cents total value. The feed cost to produce this broiler is 32 cents and represents 65 percent of the total production cost. Thus anything affecting feed costs in broiler production has a very pronounced effect on the cost of the product.

In the production of commercial eggs, it costs about \$6.15 to maintain a hen for 12 months of lay. Feed cost for this hen is about \$4 or 65 percent of the total costs. Thus it is apparent that any improvement in the feed in the way of increased production or decreased cost would have a very decided effect on total production costs.

Since feed represents well over half the production costs, it would be of interest to look at this in more detail. The following is a general formula for a poultry ration developed by the writer many years ago as a teaching aid:

#### General Formula for a Poultry Ration:

|                             | <u>Percent</u> |
|-----------------------------|----------------|
| Cereal or Cereal Byproducts | 60 to 65       |
| Plant Protein Supplements   | 20 to 30       |
| Animal Protein Supplements  | 3 to 5         |
| Alfalfa Meal                | 3 to 5         |
| Mineral Supplements         | 2 to 4         |
| Vitamin Supplements         | 1 to 2         |

It is obvious that the cereal or cereal byproducts are important as they account for almost two-thirds of the total ration. Plant protein supplements make up almost one-third of the total ration. This at the present time is primarily soybean meal and it is here that improved cottonseed meals could be used.

Poultry rations must contain from 15 to 25 percent protein and this must be of high quality. Cereal grains contribute less than one-third of the protein of the ration although

they make up over two-thirds of the entire ration. The plant protein supplements such as soybean meal, cottonseed meal, peanut meal, or sesame meal contribute 60 percent of the protein to the ration. A small amount (8 percent) is contributed by expensive animal protein supplements because they complement the inadequacies of the plant protein supplements. Alfalfa meal is added primarily as a vitamin and pigment source but contributes about 2 percent of the protein of the entire ration. It is obvious that the primary protein source for poultry rations is the plant protein supplements. This, then, would be the place where improved cottonseed meals would find a ready use.

It is of interest to break down the ration by cost of each ingredient so that some monetary value might be assigned to the plant protein supplement. It is assumed that feed costs \$4 per hundred pounds. Of this, the corn would represent slightly over \$2 or roughly 50 percent of the cost. The next in importance would be soybean meal (\$95 per ton) which would cost \$1.28 or about 30 percent of the total cost of the ration. Fish meal, alfalfa meal, and mineral and vitamin supplements make up the remaining 20 percent of the cost. If improved cottonseed meals could be used in poultry rations, they would be competing with soybean meal for approximately one-third of the cost of the ration.

Assume for the moment that improved cottonseed meals could replace one-half of the soybean meal in the poultry ration without a decrease in quality (this has been possible for a number of years for top-quality cottonseed meals and is presently being done on a large scale in California). Soybean meal presently selling for \$95 per ton would add \$1.28 to the ration cost due to its inclusion. If, however, an equal mixture of this soybean meal and improved cottonseed selling for \$85 per ton were used the ration cost would be \$1.17 or a reduction of 11 cents per 100 pounds (\$2.20 per ton) in ration cost. This may seem small but an illustration of its actual importance to an operation consuming 500 tons of feed per week is that it would result in a saving of \$1,100 per week over present costs.

On the other hand, if it is assumed that cottonseed meal can completely replace soybean meal, the picture looks even brighter. Cottonseed meals have been produced

experimentally that can completely replace soybean meal in poultry rations, so this is possible. It may increase the cost of production of cottonseed meal, however. In this case the cost of such improved cottonseed meal is assumed to be \$90 per ton with the soybean meal costing \$95 per ton. Complete replacement of the soybean meal in the poultry ration would result in reduction in cost of the final ration of 15 cents per hundred or \$3 per ton. The same operation cited above consuming 500 tons a week would reduce their weekly costs by \$1,500. It is the writer's opinion from years of counseling with feed mills that, if such improved cottonseed meals were available, they would readily be used in poultry feeds as this reduction in cost is appreciable.

The question could be asked, "Why aren't cottonseed meals being used if such reduction in costs can be effected?" There are two major problems. One is the presence of gossypol in commercial cottonseed meals. This substance is toxic if present in high enough concentrations and retards growth. Swine are very sensitive to gossypol toxicity but poultry are not so sensitive to this toxicity. However, gossypol will be deposited in the egg by hens and can cause discoloration of the yolk and this is an extremely sensitive mechanism. Cottonseed meals containing amounts of gossypol well below the toxic levels for growth will cause yolk discoloration. A second problem is the effect of heat on the protein. With many processes, the removing the oil from the cottonseed meals results in the overheating of the meals causing reduction in the nutritional value of the meals. This is further complicated by the fact that gossypol will react with the protein to further reduce the nutritional value. The research over the last 20 years has established conditions of processing which, if followed, would result in meals of high nutritional value and which could be used to replace at least one-half of the soybean meal in the ration. For a number of years now California has been using large tonnages of cottonseed meal in laying rations by first testing the meals to be sure that they will not cause egg yolk discoloration. What is even more important, processes have been developed that would even further improve the cottonseed meals and permit unlimited substitution in poultry and swine rations. An example of this is the mixed solvent extraction. Unfortunately, the many factors that could be incorporated into processing to improve the cottonseed meals have

affected the quality of the oil, reduced the tonnage processed per day, or required major changes in equipment. Because of these, much that has been done to establish conditions by which improved cottonseed meal could be produced has not been put into practice.

As sources of protein in animal rations become more critical from the reduction in supply due to competition with the human, it will become more important to produce the highest quality protein supplement possible. An evaluation of this in terms of where cottonseed meal stands would be of interest. Protein quality of protein supplements may be summarized by the following factors:

- (1) The presence and amount of the essential amino acids contained in the supplement.
- (2) The availability of these to the animal.
- (3) The most desirable balance of the amino acids as excess of certain amino acids are as harmful as deficiencies.
- (4) Whether interfering materials are present in the supplement that will affect its value--such as antitrypsin in soybeans, gossypol in cottonseed.

The amino acid content of cottonseed protein is good. It compares very favorably with soybean protein as illustrated in figure 1. Soybean protein has been assigned an arbitrary value of 100 for its content of each of the amino acids shown. Cottonseed protein is then expressed as a percentage of soybean protein for each of the amino acids shown. It will be observed that cottonseed contains less isoleucine, leucine, and lysine than soybean protein and is equal to or exceeds soybean in all other critical amino acids. The proteins of the cereal grains are good sources of isoleucine and leucine so these two amino acids are not critical in formulating rations. The only deficiency of practical importance is lysine and here cottonseed has approximately 90 percent of the value of soybean. Therefore, it could be concluded that cottonseed compares very favorably with soybean from the amino acid makeup of the protein.

However, in the area of availability the amino acids in cottonseed meal leave much to be desired. Figure 2 shows this quite clearly. In this figure the percent avail-

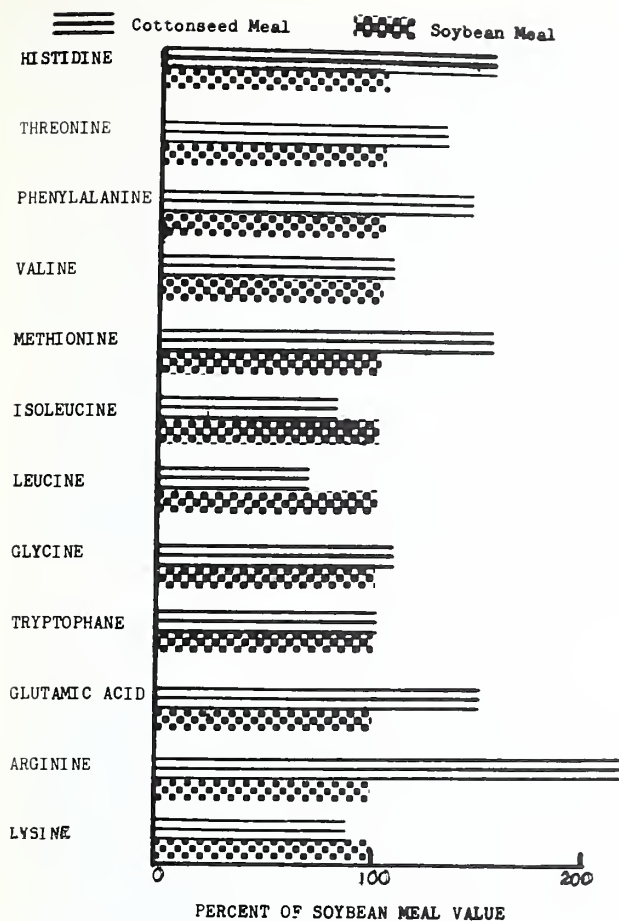


Figure 1.—The amino acid composition of cottonseed meal compared to soybean meal.

ability of certain of the critical amino acids are shown. These data are from digestibility studies with chickens at Louisiana State University. The availability of these amino acids in commercial soybean meal ranged from 80 to almost 100 percent. Experimentally produced cottonseed meals were fully equal to soybean meal in this respect. However, the two commercial cottonseed meals representing a reasonably good commercial cottonseed meal and a poor one were considerably below soybean meal. This very dramatically illustrates the deleterious effects of heat, particularly when gossypol is present. Such need not be the case as the newer solvent procedures can produce a very high quality product.

On amino acid balance little is known at the present time. It would be safe to say that cottonseed meal should be every bit as good as soybean meal in conventional rations.

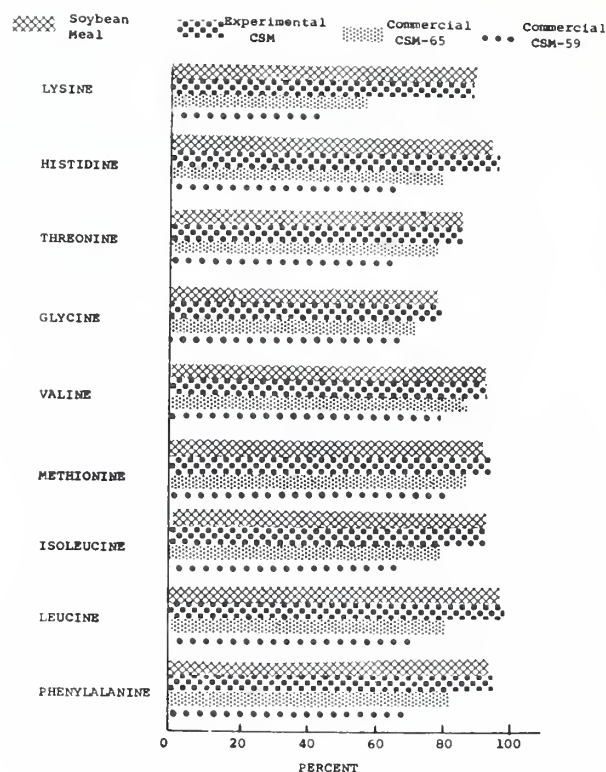


Figure 2.—The availability of certain amino acids in cottonseed meal and soybean meal.

While cottonseed has gossypol to affect its nutritional value, soybean has antitrypsin, which must be inactivated. The problem with soybean is simpler in that mild heat is necessary to accomplish this inactivation while cottonseed must have most of the gossypol removed before heating to retain the maximum nutritional value.

In summary it has been shown that the plant protein supplement is important in the ration of poultry and swine both from a nutritional, as well as economical standpoint. Improved cottonseed meals would be equal to soybean meal as a source of available amino acids and could replace either part or all of the soybean meal in the ration. When such cottonseed meals are produced, the price for them would approach that of soybean meal. However, the competition between the 2 would probably result in a reduction in the price of soybean meal. The writer believes that the price of cottonseed meal would increase more than the price of soybean meal would decrease and this could well result in the price of cottonseed meal in the magnitude of \$10 per ton.

A. Jenkins,<sup>1/</sup> Chairman

## IMPROVEMENT OF COTTONSEED MEAL BY ADDITIVES

by  
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### Introduction

Many of you have heard about a compound called gossypol that is supposed to be a notorious agent which causes oil color problems and restricts usage of cottonseed protein concentrates. Let us direct our attention to what appears to be another notorious compound, and one that acts in several ways like gossypol. This second compound has been consumed by humans at the rate of 10 to 20 million pounds per year during the past 10 years (1). This chemical and its close relatives are the third most common cause of death from acute poisoning in England and account for 15 percent of hospital admissions for poisoning (2). Examination of the stomachs, via gastroscopes, of normal persons ingesting this compound revealed hemorrhages in the stomach lining of one-half to three-fourths of the subjects examined, and 70 percent of those ingesting the compound lost an average of 5 milliliters of blood per day (3). In addition to the serious problems already mentioned, this compound has been shown to cause ulcers, gastritis, anemia, reduced red blood cell life and synthesis, depression, poor appetite, vomiting, weight loss, and hepatitis in humans, cats, dogs, and rats (4, 5, 6, 7, 8). Many of you have consumed this material in the past few hours. What is this toxic material? Not gossypol but common aspirin.

Now that it becomes apparent that a toxic material like aspirin can greatly benefit mankind, let us turn to gossypol and see if we can counteract undesirable effects by suitable additives. In this paper cottonseed meal additives such as amines, amino acids, and minerals will be reviewed with major emphasis placed upon the role of iron in counteracting gossypol toxicity.

### Amines

Since the review of amine treatment of cottonseed meal was presented at the 1961

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Valley Oilseed Processors Clinic, no new work in this field has come to the attention of the author. Amines will tie up gossypol, have been used on commercial-type cottonseed meals, have been shown to improve nutritive value, and are harmless in some forms, but are not being purposely added to cottonseed meal to tie up gossypol as far as the author is aware.

### Amino Acids

Certain amino acids make excellent additive for cottonseed meal. Whether they are added as synthetic amino acids, fermentation products, or through natural proteins, or not added, depends primarily upon price of the additives and competing materials. The amino acid which usually yields the greatest growth response when added to cottonseed meal is lysine. A review of the beneficial aspects of supplementing cottonseed meal with lysine may be found on pages 29 to 32 of the Proceedings of a Conference on Cottonseed Protein for Animal and Man, held in New Orleans in November 1960, and sponsored jointly by Southern Utilization Research and Development Division (SURDD), United Nations Children's Fund (UNICEF), and the National Cottonseed Products Association (NCPA).

After lysine requirements are satisfied, addition of methionine to cottonseed meal usually gives an increase in either or both weight gains and feed efficiency. After both lysine and methionine have been added, the next most responsive amino acid is open to question. For a review of the subject, the interested reader is referred to "Cottonseed Meal for Poultry: From Research to Practical Application," by R. A. Phelps, World's Poultry Science Journal, In press.

### Minerals

Calcium. --In 1935 the late Gallup and Reder (9) reported not only was solubilized

gossypol precipitated by calcium under alkaline conditions, indicating some type of reaction between the mineral and gossypol, but also that 1.2 percent calcium in the ration permitted rats to approximate a normal growth rate even when receiving 525 parts per million (0.0525 percent) of gossypol. The detoxifying ability of calcium appeared to be confirmed in a later study by the same authors in which an even higher level of gossypol was fed to rats (10).

Approximately 20 years later Eagle and others (11) reported that toxic cottonseed meals could be detoxified with several alkalies, including calcium hydroxide. The hydroxides of sodium, potassium, and the ammonium ion, however, appeared to be more effective.

Heath and Lindstrom (12) confirmed that gossypol complexed with calcium.

Bressani, and others (13), reported in the 1964 Proceedings of a Conference on Cottonseed Protein Concentrates, a conference jointly sponsored by the NCPA, SURDD, and UNICEF, that addition of calcium to a cottonseed flour mixture caused a reduction in both free and total gossypol. Swine feeding trials indicated that a mixture of calcium hydroxide and ferrous sulfate appeared to protect pigs against gossypol toxicity, but the calcium hydroxide was not tested in the absence of iron.

Although the cited studies with rats indicated that calcium would detoxify gossypol when growth was used as the criterion, research underway with swine in North Carolina indicates that calcium will not protect pigs from mortality attributed to gossypol. Smith (14) reported that the calcium appeared to change gossypol so that it is not analyzed as gossypol, but the altered gossypol is still toxic.

Copper and zinc. --Although copper and zinc have been shown to complex with gossypol (12), neither metal protected pigs from gossypol toxicity in recent experiments at North Carolina (15).

Iron. --Studies of iron additions to cottonseed meal are so numerous that it seems best to divide them into (1) fundamental, (2) rabbit, (3) rat, (4) swine, and (5) laying hen studies.

(1) Fundamental iron-gossypol studies. In 1917 Withers and Carruth (16) reported formation of a brownish-black color when either cottonseed meal or a solution of gossypol was treated with iron salts. Gallup (17) reported that iron reacts almost immediately with a solution of gossypol in a test tube. In more recent times Jonassen and Demint (18) found that gossypol strongly bound iron, or vice versa, in a 1:1 molar ratio. They believed iron bound to gossypol via perihydroxyl groups. Hass and Shirley (19) of the University of Tennessee questioned this proposed site of binding, but no one seems to question that iron does bind to gossypol. Iron also oxidizes gossypol to gossypolone (19).

(2) Rabbit studies with iron and cottonseed meal. In 1913 Withers and Brewster (20) found that iron from ferric ammonium citrate would protect rabbits from gossypol toxicity. Iron-fed rabbits ate about 5 times more cottonseed meal than those receiving the cottonseed meal ration without iron.

(3) Rat studies. Gallup (17) reported ferric citrate and ferrous ammonium sulfate would protect rats from toxic effects of cottonseed meal but that ferric oxide was of no value. Gallup also showed that a much higher ratio of iron to gossypol was needed to protect rats from gossypol toxicity than was required to complex with gossypol in a test tube.

Olcott (21) confirmed Gallup's finding that ferric oxide would not detoxify cottonseed meal. Olcott also learned that iron was effective in counteracting toxicity of cottonseed meal only if the cottonseed meal ration and iron were fed during the same 12 hour period. This observation lent support to Gallup's contention that iron detoxified by forming a nonabsorbable complex with gossypol. Addition of ferric ammonium citrate to drinking water of rats appeared to protect them from toxic effects of gossypol.

In 1949 Eagle (22) showed quite conclusively that ferrous sulfate would protect rats from large, single doses of gossypol, the highest dose tested being 7 grams per kilogram.

Clawson, and others (23) reported that injected iron, but not oral iron, protected

rats from deleterious effects of injected gossypol. Danhof (24) has shown that oral iron, but not injected iron, will protect rats from orally administered gossypol. The data thus lend further support to the contention that a direct reaction of gossypol with iron is the means by which iron inactivates gossypol.

Danke and Tillman (25) have reported recently that although iron protected rats from gossypol toxicity, animals receiving high levels of gossypol in the absence of iron developed anemia, thus indicating a possible effect of gossypol on iron within the body of rats. The anemia changed from the small red blood cell, normal color type, to small cells of pale color as the gossypol feeding period increased from 2 to 4 weeks.

In other recent rat studies, Stevenson and others (26) reported the following iron compounds to be effective as detoxicants for cottonseed meal: ferrous fumarate, ferrous sulfate, ferric citrate, ferric ammonium citrate, and ferrous oxalate. Ferric oxide, in confirmation of the studies of Gallup and Olcott, did not appear to be effective.

(4) Swine studies. In 1917 Withers and Carruth (16) showed that iron was at least partly effective in protecting pigs from toxic effects of cottonseed meal. Robison (27) showed that levels of iron ranging from 585 to 640 parts per million (0.05 to 0.06 percent), supplied by ferrous sulfate, protected pigs from cottonseed meal toxicity if the iron was applied as a solution, but not if the iron was applied in the dry form and the feed moistened just before consumption. Robison also learned through an accident that the very high level of 0.2 percent iron was not toxic to pigs. Fletcher (28) also reported that ferrous sulfate protected pigs from cottonseed meal toxicity.

In recent years Lyman and Hale (29) conducted several swine experiments that not only showed that iron would protect pigs from gossypol effects but they also provided a better understanding of how iron exerts its beneficial effect. Much of these data are unpublished, but some can be found in the Proceedings of the 1963 Texas Nutrition Conference. Portions of these data are illustrated in figures 1, 2, and 3. It is obvious that iron not only kept the animals alive, but also increased gains and feed efficiency in most experiments. The data also show that

supplemental iron in the ration decreases deposition of gossypol in swine livers, an observation reported earlier by the North Carolina Workers.

Related studies by Clawson and others (23) showed that as the ration level of gossypol increased, gossypol in swine livers also increased, but liver iron decreased. Additional swine studies Smith and Clawson (15) at North Carolina State University at Raleigh have shown that although a 0.5:1 ratio of iron to gossypol may provide sufficient iron to detoxify low levels of gossypol in swine rations, a ratio, by weight, of 1:1 is needed to counteract high levels of gossypol. Results of this trial are shown in figure 4. A second trial has now confirmed the need for the 1:1 ratio of iron to gossypol.

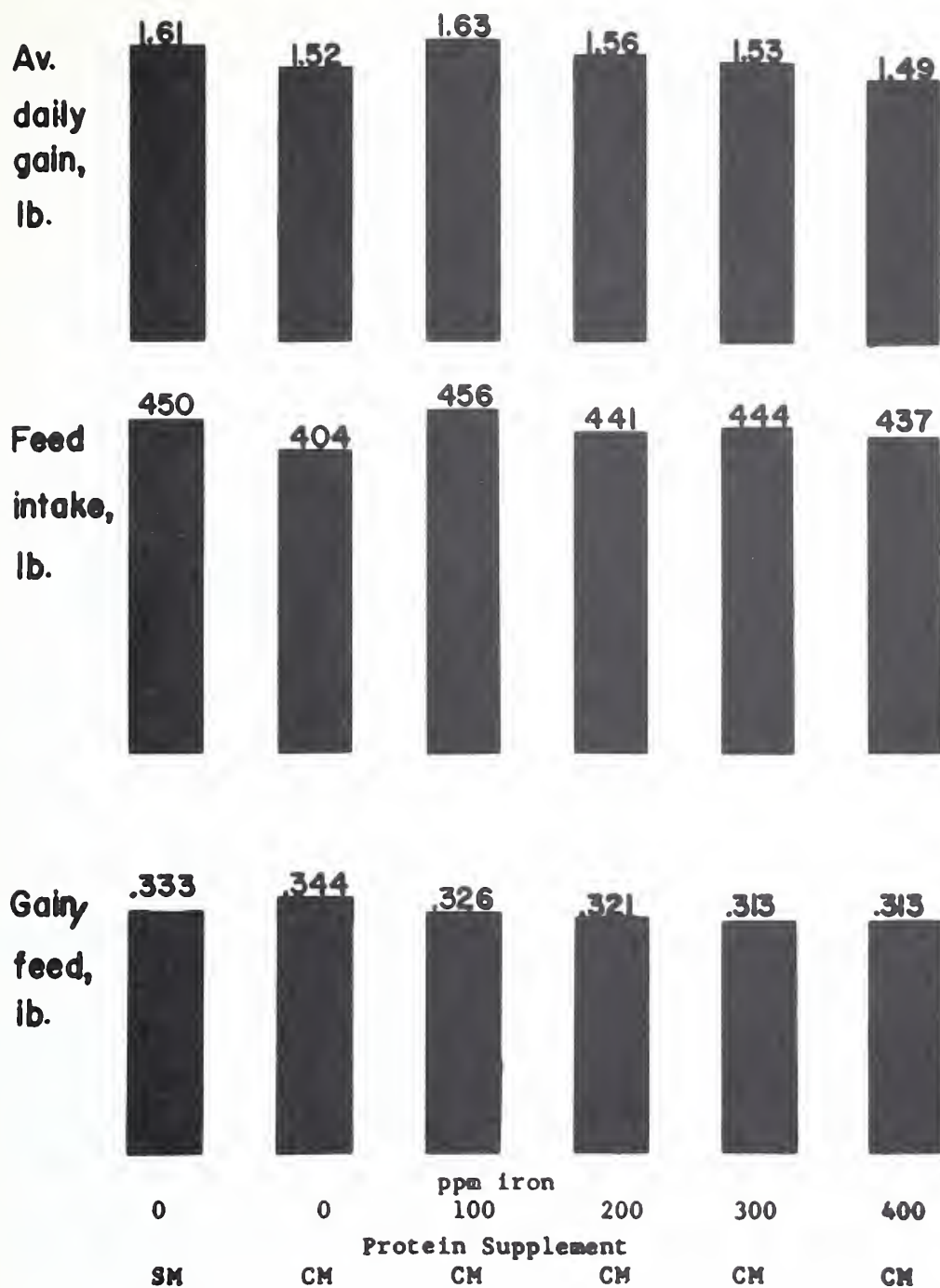
Additional studies which show successful counteraction of gossypol toxicity in swine by iron may be found in the reports of Stevenson and others (26) and Bressani and others (13).

(5) Laying hens studies. In 1934 Schaible and others (30) reported that 0.2 to 0.4 percent iron in the ration protected against olive yolk discoloration when up to 40 percent of cottonseed meal was fed.

In 1942 Swensen and others (31) showed that dark yolks from feeding gossypol or cottonseed meal was due to a gossypol-iron complex, later confirmed by Kemmerer and others (32), and that as hens were fed increasing levels of iron, increasing amounts of gossypol were found in the droppings. Thus the three studies cited indicated that iron participated in both the cause and control of dark yolk discoloration. Swensen and others (31), also confirmed earlier studies of Withers and Carruth (16) that iron added to cottonseed meal caused a darkening of the meal, but recent studies, to be reported below, have shown that neither black droppings nor dark meal are experienced when dry forms of ferrous sulfate are employed.

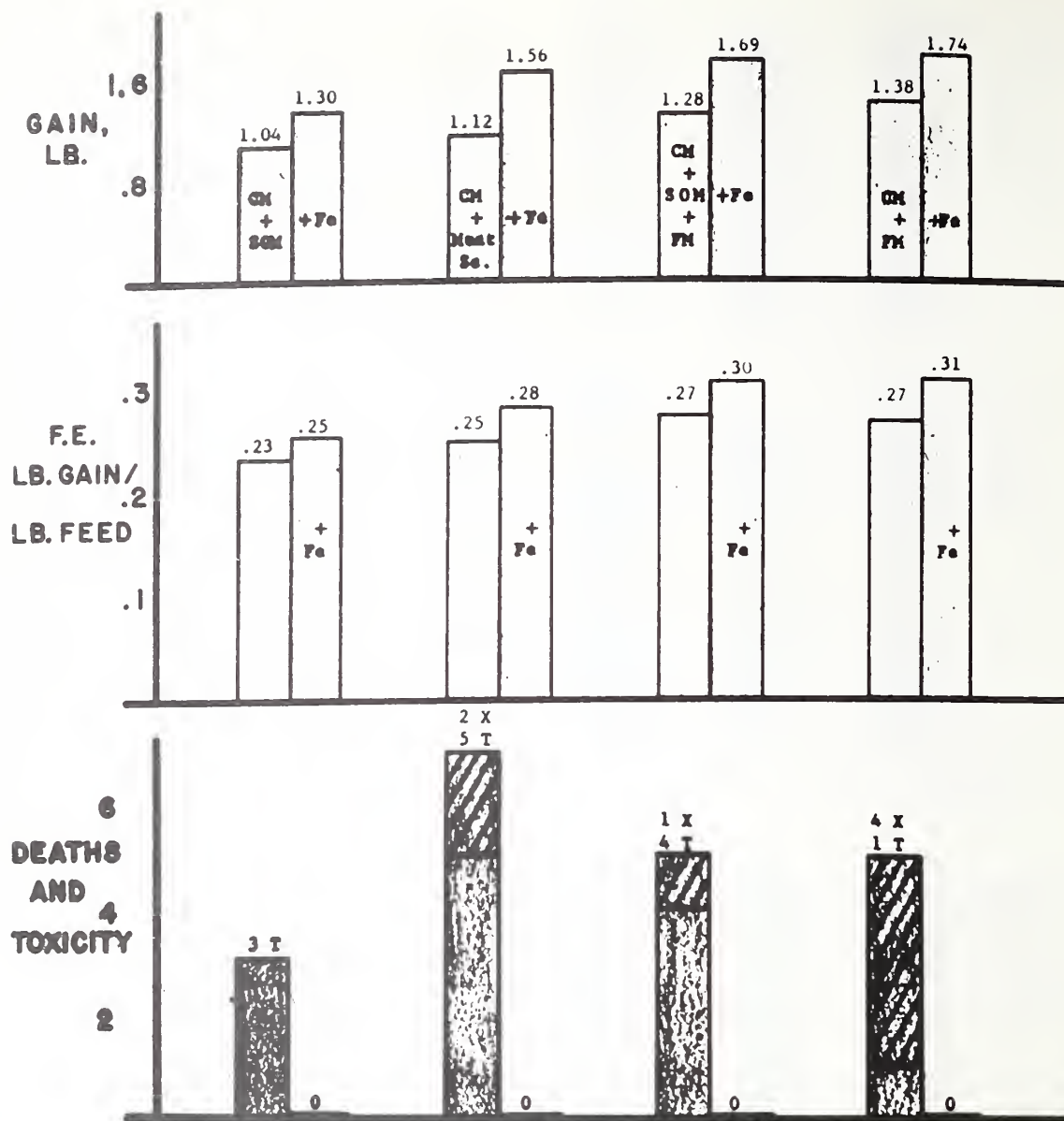
In 1953 Fletcher and others (33) reported 95 percent of stored eggs were normal after a 300 parts per million gossypol cottonseed meal ration was supplemented with 1,000 parts per million (0.1 percent) iron. When the gossypol ration was fed without supplemental iron only 7 percent of the eggs were normal.

In 1957 Heywang (34) reported that ferrous sulfate would not prevent dark yolk



(Double bar on gain/feed of soybean meal(S M-O) and cottonseed meal, no iron (CM-O) lots refer to two different calculations for each ration necessitated by inclusion or omission of one "problem" pig in each lot.)

Figure 1.—Effect of iron on swine fed high gossypol cottonseed meal.  
(Data of C. M. Lyman and Fred Hale)



(All rations contained 190 p.p.m. free gossypol, 74-78% milo, 10% cottonseed meal, 3% Dehi, 1.3% ground limestone, 0.5% zinc-salt mixture, 0.1% aurofac 10, 0.5% vitamin premix, and same protein level. Variables included 400 p.p.m. iron (as  $\text{FeSO}_4 \cdot 1\text{H}_2\text{O}$ ) with (a) 10% soybean oil meal, (b) 7% meat scraps, (c) 4.3% each of soybean oil meal and fish meal, or (d) 7% fish meal as the source of supplemental protein.)

Figure 2.--Effect of iron on 77-day swine gossypol toxicity.  
(Data of C. M. Lyman and Fred Hale)  
10 Pigs per Lot

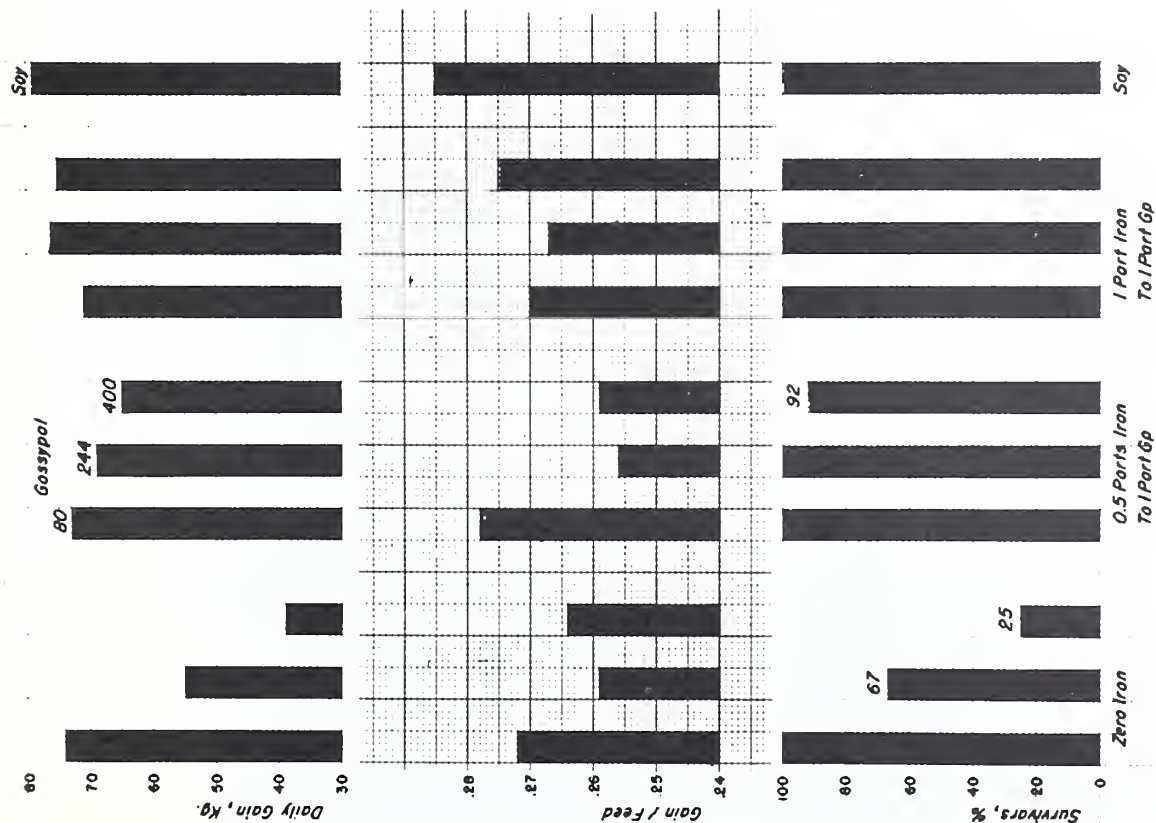


Figure 4.—Detoxication of gossypol by iron.  
(Swine data of F. H. Smith & A. J. Clawson).

Liver Gossypol, p.p.m.

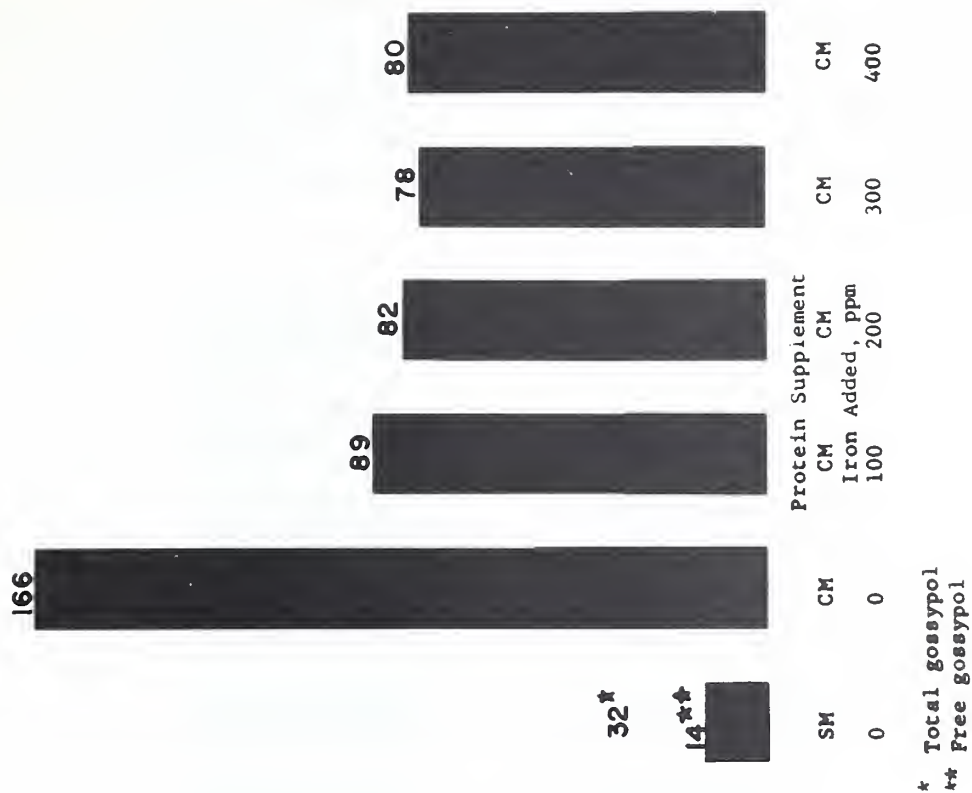
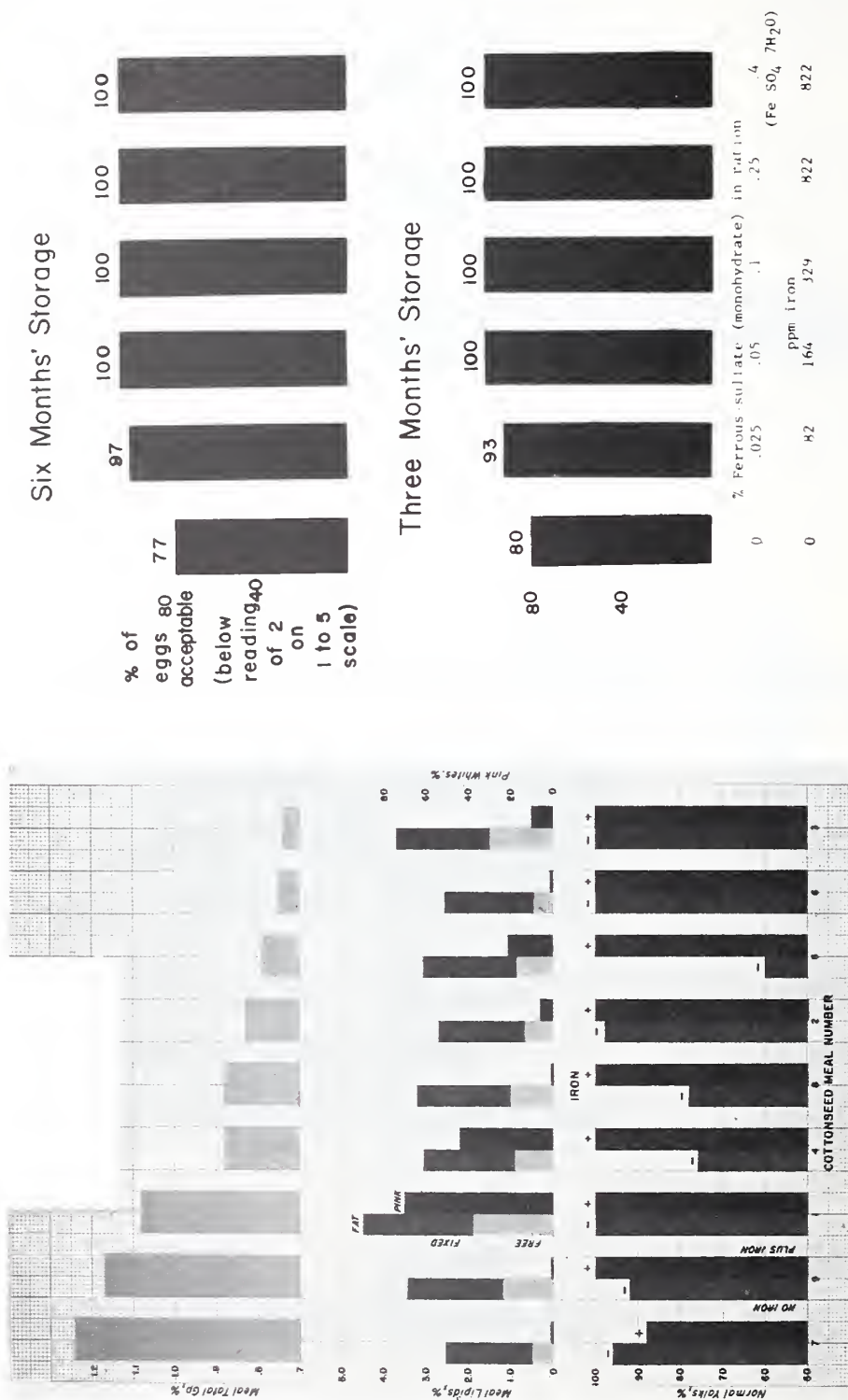


Figure 3.—Effect of ration iron on swine liver gossypol.  
(Data of C. M. Lyman and Fred Hale)

discoloration in eggs from hens fed cottonseed meal. In light of recent knowledge it appears likely that the high fat content of some of the cottonseed meals employed may have adversely affected the results since half of the eggs had pink whites when some of the rations were fed.

With the newer knowledge that laying hen rations must be kept low in cottonseed oil, including residual oil of cottonseed meals, to prevent pink whites and associated defects in eggs, it seemed likely that counteraction of dark yolk discoloration by iron could be effected. Data shown in figures 5 and 6 illustrate that



(All rations contained 20% level of commercial cottonseed meal (0.02% free gossypol and 0.5% fat in meal)  
Figure 5.—Effect of iron on stored egg color.  
(Data of B. W. Heywang and A. R. Kemmerer)

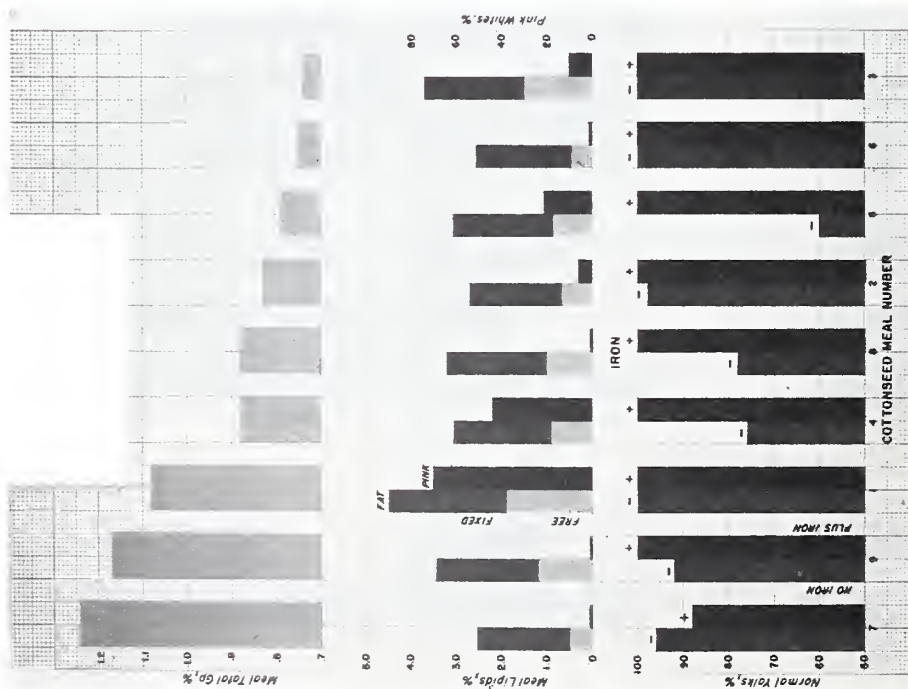


Figure 6.—Elimination of yolk discoloration by iron.  
(Data of B. W. Heywang and A. R. Kemmerer)  
(Three months' storage data)

commercial cottonseed meals can be fed up to at least 15 percent level without yolk discoloration problems, even when the eggs are stored for prolonged periods, if cottonseed meals are (1) low in residual fat, (2) low in free gossypol, (3) moderate or low in total gossypol, and (4) supplemented with the proper level of iron.

### Conclusion

After reviewing all available studies in which iron was added to cottonseed meal, one wonders why we have had to wait 50 years to put the research data into commercial channels. Possibly there are major hurdles which we can never surmount, and thus we may fail to take advantage of all of the research which has gone on before us. After the forthcoming gossypol-metal conference is held, we should all be in a better position to assess the future role of iron and possibly other metals in counteracting gossypol toxicity.

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### DISCUSSION

Question: I'd like to ask whether your calculation of amount of iron or molar ratio was based on free gossypol or total gossypol, in other words, 1:1 ratio, is that free or total?

Dr. Phelps: That is on the free gossypol basis in all cases. The 1:1 ratio is on a weight basis, not molar basis.

Question: In all cases on the free basis?

Dr. Phelps: Yes, free gossypol basis. I am not sure it should be in the case of the laying hen, based on the data I showed you, but in swine work, where the animals were completely protected against toxicity, it has been on the basis of ratio of iron to free gossypol. In other words 100 grams of iron from ferrous sulfate would protect against 100 grams of free gossypol.

Dr. Jenkins: Another question?

Question: Was the ferrous sulfate in all cases added as a dry material to the diet or was there some moisture added with it, and if so, how does this correlate with the earlier rat experiment that you talked about where the man had to add moisture to the diet, or is there any explanation for this?

Dr. Phelps: I do not know what the explanation is, but in all of this work the iron (ferrous sulfate) has been added as a dry form. The studies with iron solutions added to swine rations were carried out by Robison of Ohio. He was using the seven-water form of ferrous sulfate. In most of the more recent studies the one-to-two water form of ferrous sulfate, or exsiccated form, was used. I would not, however, think it would be of any significance in regard to your question. It is possible that the high fat content meal used in the past necessitated some moisture addition to make the iron more effective.

The reason we settled on the exsiccated form was the fact that Dr. Lyman was a little concerned that the seven-water would darken the feed. Some of the seven-water form has been used in recent experiments with no noticeable darkening of feed.

Secondly, we have been told that the seven-water form contains quite a few impurities, and we did not want to complicate the problem with those impurities.

Right now in Arizona, Burt Heywang and Art Kemmerer have an experiment underway in which, in every lot, they are evaluating the one-water form of ferrous sulfate in the ration versus the seven-water type.

Question: Did you say there was no correlation between incidence of pink white and fat content of the meal?

Dr. Phelps: In the particular experiment mentioned there was a very poor correlation. The prepress solvent meals employed ranged from 1.91 percent fat down to about 0.45 percent. The 1.91 percent fat meal produced the most pink eggs and the 0.45 percent fat meal did not produce any. The data considered as a whole, however, showed a poor correlation between fat content of the cottonseed meals and incidence of pink whites.

Question: Another question: Does this dry iron mix treatment work with straight hexane-extracted meals?

Dr. Phelps: Yes. The Texas and North Carolina workers were using direct

solvent meals in the swine work, and the iron did counteract the gossypol. We have not tested direct solvent meals with laying hens, but other workers have and the iron additions did prove effective.

## PRODUCTION AND UTILIZATION OF PROTEIN CONCENTRATES AND ISOLATES— SHOULD MILLS PREPARE TO PRODUCE THEM?

by  
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The past few years have brought an ever-increasing awareness of the importance of our total food supplies throughout the world. Even in the past year we have become much more acutely conscious of the responsibilities that we in high producing nations have to help feed those people who are in less fortunate circumstances than we. In practically every journal we pick up now we see discussions of this problem of supplying sufficient food to meet our human needs throughout the world, and we are all becoming much more familiar with the kind of statistics involved. Even some of our demographers seem to have been caught quite by surprise to find that we already have approximately 3 to 3.2 billion people in this world in 1966, whereas forecasts a few years ago did not predict such levels until several years hence. And now we are faced with the additional realization that there will probably be approximately 6 billion people on the surface of this earth by the year 2000.

All of this has served to put additional emphasis on the importance of all of our oil seeds in helping meet the needs for protein for humans, either directly or indirectly.

There has been an increased emphasis on the production of some of our oil seeds and there has also been an increased export of some of the oil seeds or their products, meal and oil. For the purposes of this discussion, we are interested in the total supply available over the most recent period for which we have statistics, something about how these stocks were used, and how we might increase the use of cottonseed meals.

The total supply of oil meals available for the year October 1964 through September 1965 was 14,618,000 tons. As indicated in table 1, 11,286,000 tons of this supply was soybean meal, 2,767,000 tons was cottonseed meal, with linseed, peanut, and copra making up the balance. By far the biggest user of these products, which are both cakes and meals, is the feed use. Of the total 14,618,000 tons, 12,414,000 tons were used for animal feeds. Two million two hundred forty-eight thousand tons were exported. Approximately 60,000 tons were used for industrial purposes and for fertilizer, and the remaining 199,000 tons are accounted for in differences in inventory and in remaining inventory. These figures, of course,

Table 1. --Oilseed cakes and meals, supply and distribution, U. S.  
October 1964-September 1965<sup>1/</sup>

| Product    | Production      | Feed            | Export          |
|------------|-----------------|-----------------|-----------------|
|            | (Thousand tons) | (Thousand tons) | (Thousand tons) |
| Soybean    | 11,286          | 9,236           | 2,036           |
| Cottonseed | 2,767           | 2,680           | 139             |
| Linseed    | 366             | 300             | 73              |
| Peanut     | 98              | 98              | -               |
| Copra      | 101             | 100             | -               |
|            | 14,618          | 12,414          | 2,248           |

<sup>1/</sup> Preliminary

are for the United States. In many other countries, we are looking to cottonseed flour and meals more and more to help provide the protein required by humans directly. And we might also add that in spite of the dominance of soybean meal supplies in this country, many of the countries where we have food shortages today have a much better opportunity to grow cotton economically and profitably than they do the soybean. Therefore, cottonseed flours and meals must take a more prominent part in direct human nutrition in many areas of the world today.

The figures we have quoted above have been for total feed usage. I think the figures used in manufactured feeds are very interesting.

We have contrasted the usage over a 2-year period in table 2. It is very interesting

on the market which are more suitable for use over a wider variety of animal feeds than we have had in the past. I am speaking here, of course, of lower fiber, higher protein meals which are being produced in certain areas, particularly the West Coast. And last but not least, we must give credit to the Research and Education Office of the National Cottonseed Products Association for doing a fine job in educating feed manufacturers to the possibilities of the use of more cottonseed meal in mixed feeds.

This brings me to one of the facets of the title which has been assigned to me. This is the question of production of protein concentrates. Should the mills prepare to produce them? For the purposes of this discussion, a protein concentrate may be defined as any product prepared from the cottonseed which is higher in protein than the original seed.

Table 2. --Soybean and cottonseed meals in formula feeds--estimated usage

| Feeds                                 | 1962         | 1964         |
|---------------------------------------|--------------|--------------|
| Total manufactured feeds (est.), tons | 44,000,000.0 | 44,000,000.0 |
| Soybean meal, percent of total        | 20.8         | 21.0         |
| Cottonseed meal, percent of total     | 2.6          | 6.1          |
| Soybean meal, tons                    | 9,200,000    | 9,236,000    |
| Cottonseed meal, tons                 | 1,100,000    | 2,680,000    |

to note that the total manufactured feeds as reported indicate almost identical tonnages for these 2 years. It is very interesting also to note that the percentage of soybean meal used in these feeds has remained almost identical. But the interesting figure is the one on cottonseed meal. In 1962, only 2.6 percent of the total was cottonseed meal, while in 1964 this figure had increased to 6.1 percent or, in tonnages, soybean meal remained virtually stationary at 9.2 million tons in 1962 and 9,236,000 tons in 1964, but cottonseed meal had increased from 1.1 million tons in 1962 to a figure of 2,680,000 tons in 1964. Certainly there are many reasons for this increase in use of cottonseed meals. I am not going to try to get into all of them today, partly because I don't know what all of the reasons are. However, I think we must give credit to an improved quality of product produced in those areas where this increase in feed usage has come, and the crushers operating in those areas certainly must be given credit for this. We must also credit the appearance of products

This, of course, includes all types of cottonseed meals. Since all plants are producing products which will go up to 41 percent protein, the question becomes simply whether the cotton crushing industry should follow the example of some of the other oilseed industries in producing higher protein concentrates than has been the common practice in the past. As a usual thing, a 50 percent protein (N x 6.25) product can be produced by removal or withholding of additional hulls. When we talk about this type of product, we are talking about use of cottonseed meal in the ration of monogastric animals. The ruminant must have a certain amount of roughage in its total ration, so there is no advantage in removing all or virtually all of the hulls from the meal that is to be fed to ruminants. Of course, there could be an exception to this if the price of hulls were unusually high and the price of other roughages exceptionally low. However, this does not usually happen, so we may limit our consideration to the use for monogastric animals.

At this point, the question of economics usually comes in. This is a problem that has faced and is facing the soybean industry when they went to a 50 percent protein product. In order to examine this question, I think we should look at the percent of the total value of the meal and oils for both soybeans and cottonseed in figures 1 and 2.

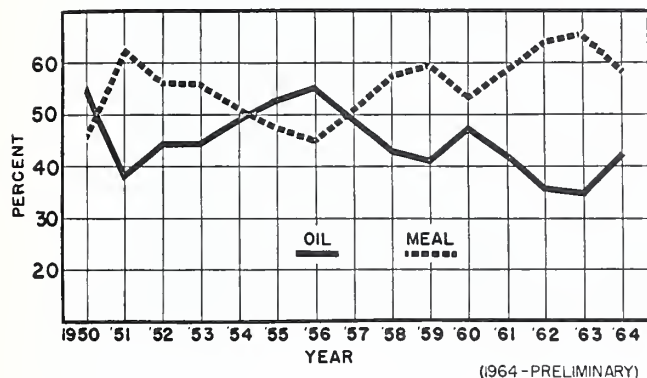


Figure 1.—Soybeans percentage of total value.

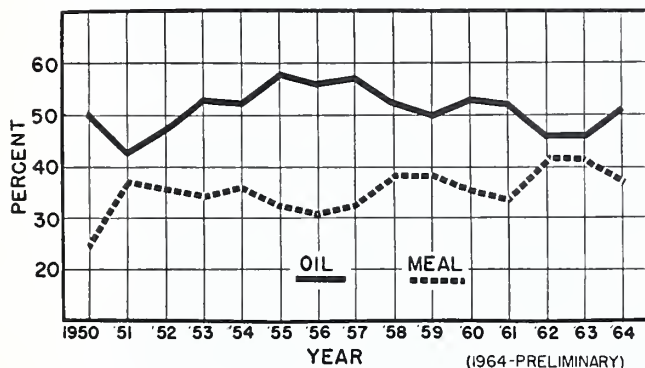


Figure 2.—Cottonseed percentage of total value.

During the last 15 years, prior to the years 1963 and 1964, both soybean meal and cottonseed meal have shown a trend to represent a higher percent of the total value of the bean or seed. The years 1955, 1956, and 1960 were exceptions to this but on the whole the trend has been quite definite. Note, however, the very sharp reversal in the 1964 year. In 1950, oil accounted for approximately 54 percent of the total value of the soybean. With fluctuations up and down, this dropped to a low point of 35 percent in 1963. Conversely, the value of the meal was 46 percent of the value of the soybean in 1950 and it increased to 65 percent in 1963. Then the sharp reversal last year with the two figures going to 42 percent for oil and 58 percent for meal.

Cottonseed oil values have been much more stable. In 1950, oil represented 50 percent of the value of the seed and this has shown some fluctuations during the course of the years but was still at 46 percent in 1963 and back up to 51 percent in 1964. Here, of course, we do not have a simple oil and meal relationship, but we must also take into account the hulls and linters. The value of the meal has risen from 24 percent in 1950 to 41 percent in 1963 and has dropped back 37 percent in 1964. This means that since the percentage of the value has remained reasonably constant, the value of hulls and linters combined has decreased and meal is carrying part of the load which has been carried by the hulls and linters in the past. Therefore, the trend in the cottonseed industry also is for the meal to assume an ever-increasing share of the cost of the total seed.

When a plant considers the production of 50 percent protein cottonseed meal, the problem of hull disposal can become painfully acute. If it is going to be profitable to produce a 50 percent meal, the total revenue from the meal plus hulls and linters must be at least the same as it is when lower protein products are produced. This then raises the question of how much more the 50 percent meal might be worth to the feed industry than a 41 percent. This is not a simple answer, because we do not make a direct substitution of 50 percent protein cottonseed meal for 41 percent. Under these conditions, protein levels are maintained at an equal level and therefore the additional formula space is available for other ingredients. This does,

of course, permit more formula flexibility and the possibility of providing higher energy feeds.

Fifty percent protein cottonseed meal has been available in California during the past year or so. So we have had some experience in using this product in formulation. We have, therefore, calculated the difference in value between 50 percent protein cottonseed meal and the 41 percent at various points throughout the country. The range in differential value was from \$7.50 per ton to \$15.50 per ton, depending upon the type of formula in which the products were used. This means that when the 50 percent protein cottonseed meal can be priced at the lower differential, that is \$7.00 to \$7.50 per ton, we will get the maximum usage of the higher protein meal. As the differential in price goes up, it will be dropped from formulas successively until it is eliminated completely at the higher figure. It must be emphasized that this is not an absolute figure but that it will vary from time to time, depending upon the value of other ingredients. If we want to make a comparison, we might look at the price performance of soybean meals which have been on the basis of higher and lower protein products for a number of years. Remember that in the soybean area we are talking about a 44 percent protein product as compared with a 50 percent. The range in differential in price has varied from \$3.50 to \$13 per ton at point of origin during the past several years. A differential of \$7.50 to \$9 per ton would be more typical over the past 5-year period.

Therefore, from the standpoint of the producing mill, the question of which type of product to produce becomes one of satisfying a market and the differential in price at which the two products will move. This will require a study on a plant by plant basis to determine the interest that the customer-user may have, because the feed manufacturer is not going to be very happy about using a product unless it is available fairly consistently, and the more consistently the better. The soybean processor has found this to be a practical solution. We think the cotton crusher can find a similar satisfactory solution and in so doing he will broaden the base of use of his product and increase the use of cottonseed meal still further in the manufactured feeds.

The second part of this subject has to do with protein isolates. I would define the cottonseed protein isolate as the proteinaceous fraction of cottonseed prepared from high-quality, sound, clean cottonseed by removing a preponderance of the nonprotein components with a resulting protein content of the isolate of not less than 90 percent protein when calculated on a nitrogen times 6.25 dry basis. When we consider this type of production, we are shifting from an oil crushing operation to a more sophisticated chemical operation. Some of the types of equipment used in producing an isolate may be illustrated by the equipment that is used in the typical soybean isolate production. I am using the pictures from the soybean industry because I don't know of anyone who is making a cottonseed isolate at this time. These isolates may be used for either industrial or edible purposes. The first view (fig. 3) is one of an edible soy protein processing area, showing the complex wet processing equipment. The equipment, piping, and so forth, meet dairy standards for sanitation. This, of course, is necessary in the plant where we are producing foods for human use. In addition to the fact that this is a chemical process, we must constantly be on guard against bacterial contamination because any wet process is particularly susceptible to the development of bacteria. Stainless steel tanks are used to store the materials in the wet process (fig. 4). And finally the product is dried in a large, horizontal stainless steel spray drier similar to those used in the milk industry (fig. 5). This type of product then results in a dry edible powder, which has been cleared for use in certain types of processed meat products. It is used primarily as a binder for this type of product. There is also a process wherein the curd, instead of going into a spray drier, may be shifted through spinnerets similar to those used in the synthetic fiber industry. This provides texture in a protein isolate product. Figure 6 shows the type of fiber that is obtained by this method.

By far the largest use for protein isolates at this time is found in the industrial area where it is used for such purposes as adhesives, paper coatings, an ingredient in paint, and so on. Figure 7 illustrates an area of an industrial soy protein plant showing part of the centrifugal equipment used in processing. In this type of production, a

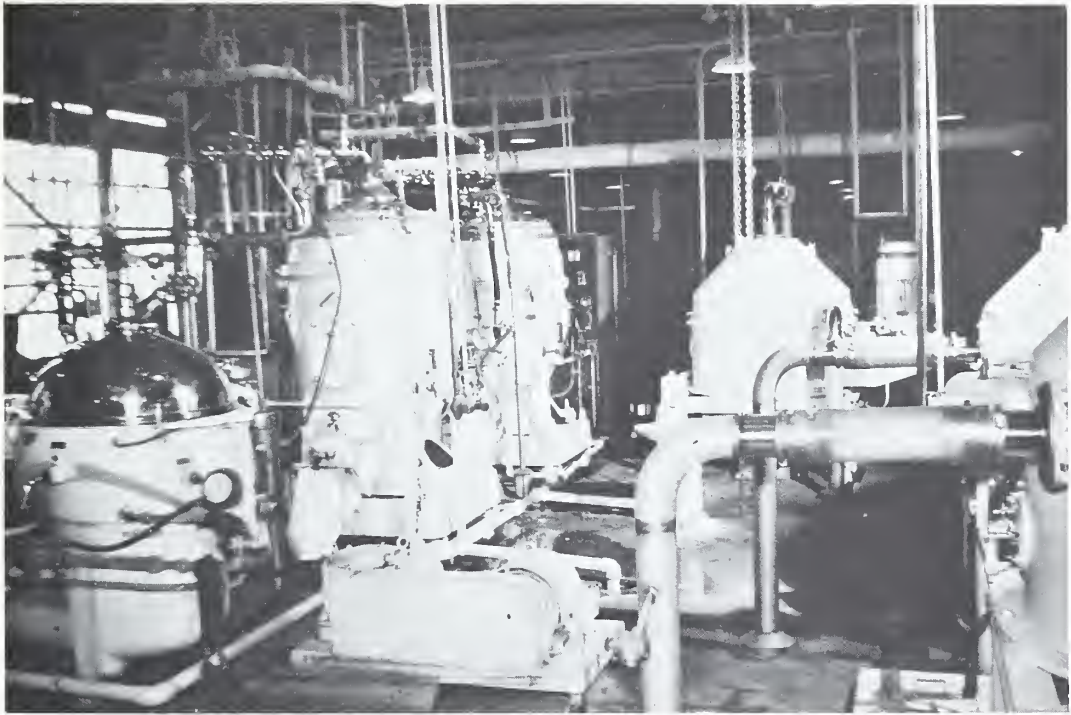


Figure 3.—Processing equipment for edible soy protein

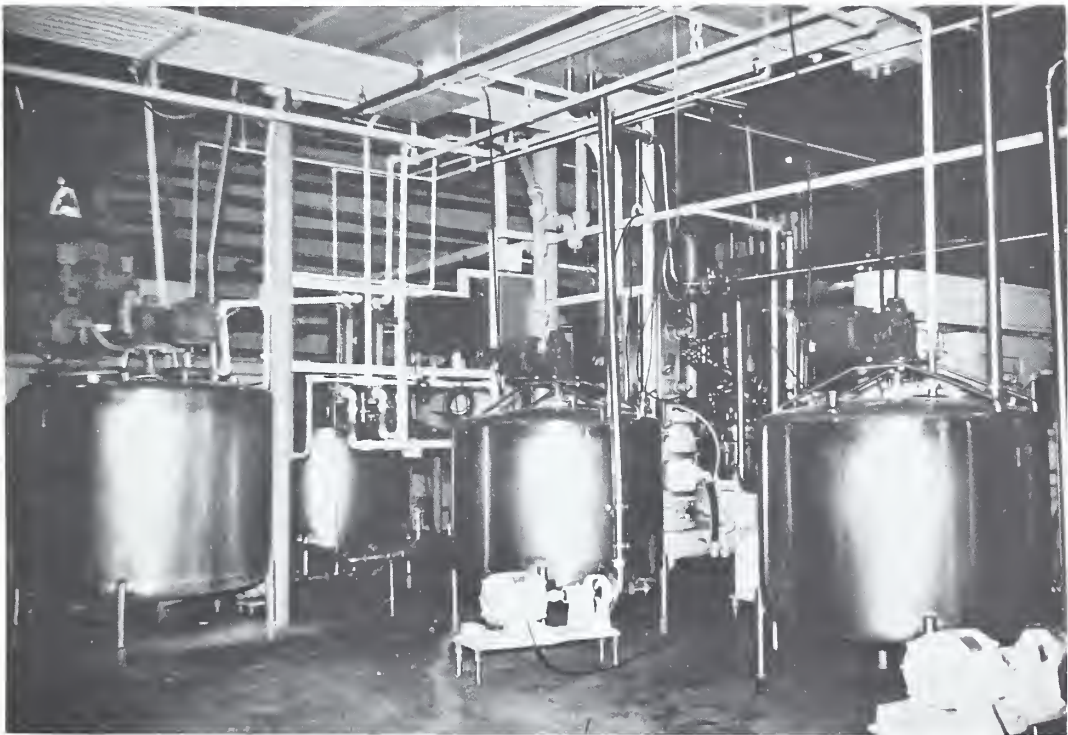


Figure 4.—Storage tanks for soy protein.

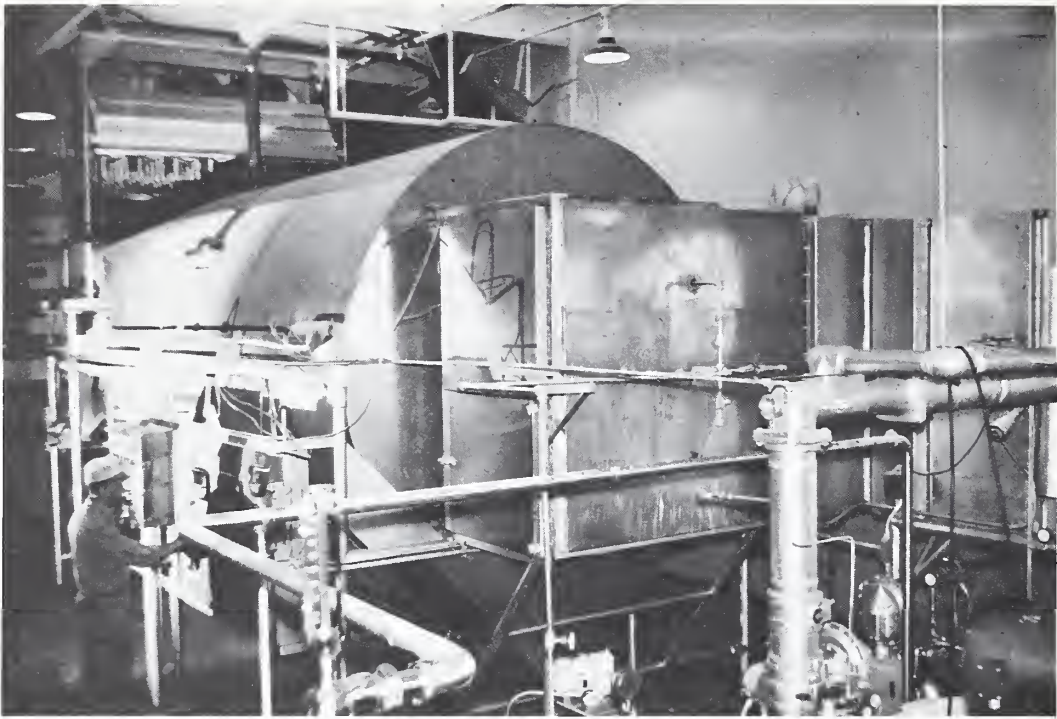


Figure 5.—Spray dryer.



Figure 6.—Soy protein fiber.

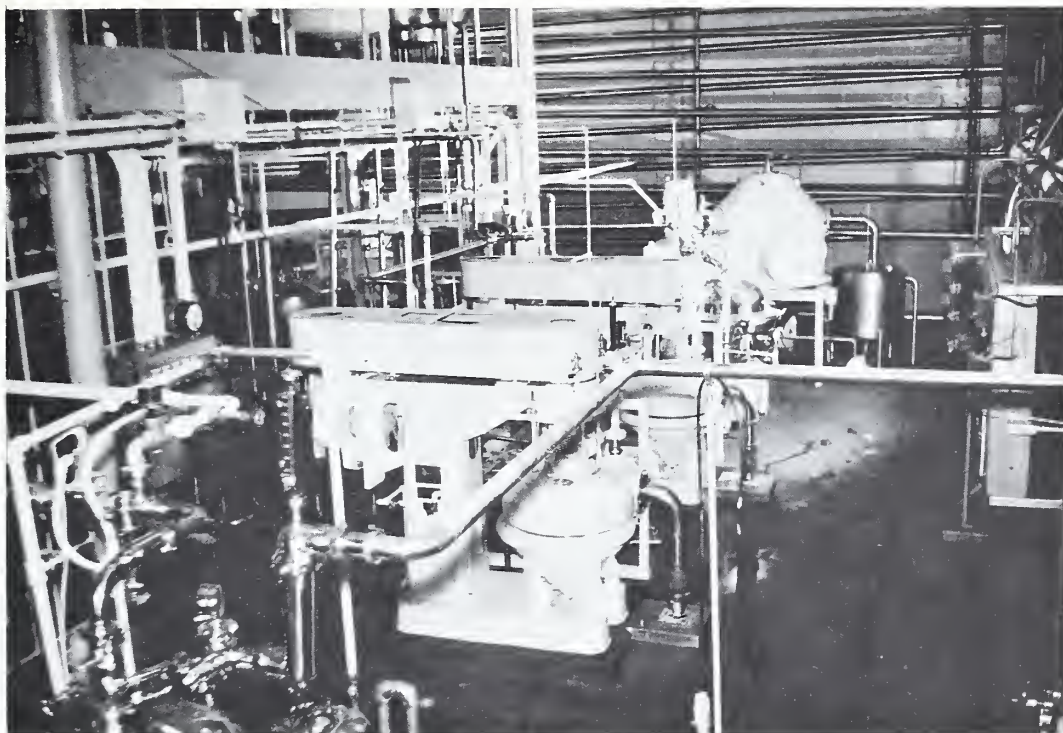


Figure 7.--Centrifugal equipment for soy protein processing.

chemical treatment is necessary and extremely large stainless steel tanks are used

in which the material is kept under constant agitation (fig. 8). Then the protein is

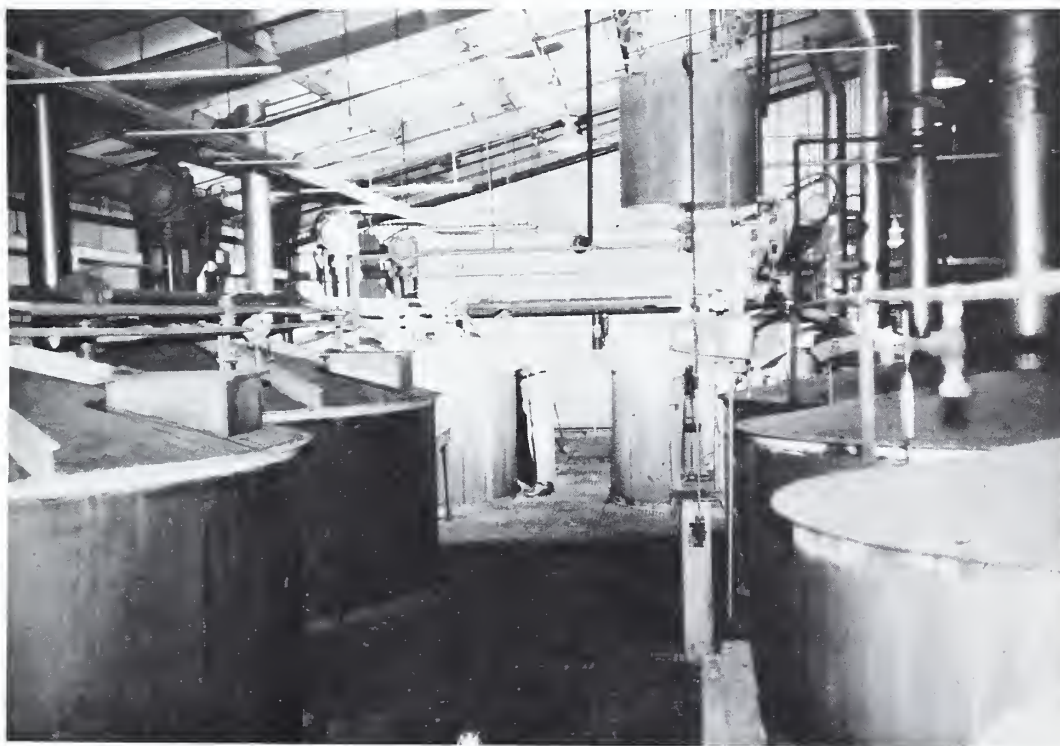


Figure 8.--Agitation tanks for preparation of industrial soy protein.

recovered as a filter cake on large rotary drum type filters just before drying.

Isolates from the soybean are finding a very useful market as both industrial and edible products at prices presently ranging from 22-1/2 cents per pound in carload quantities to 35 cents per pound per carload for edible, and higher prices for smaller amounts. At this time, the industrial market is far more extensive than that for the edible-type protein isolate. The soybean protein isolate competes with casein, in some areas it competes with starch, and in other areas it competes with synthetic plastic-type materials for the industrial protein types of market. The soybean protein isolate has found a very useful place in the uses for paper coatings, adhesives, and so forth, in the paper industry. This is a constantly and rapidly growing industry with much increased demand. The question of whether an isolate from the cottonseed will find a place in this area is still unanswered. There is work in progress now to attempt to isolate cottonseed protein so that it can be tested for these various uses. Since the cottonseed protein has many characteristics which are different from those exhibited by soybean protein or by casein, there is always the possibility that it may find a particular niche of its own in this type of market. Again,

it may have to compete with soybean protein and casein for a part of the market. And still further, it may not be practical at all for this type of use. These are questions which remain to be answered. However, I think it is apparent from the illustrations we have used here that the cottonseed crushing plant as we know it today is not adapted for the production of the protein isolate as we have defined it here today. If and when the cottonseed industry should attempt to produce protein isolates on a commercial basis, a different type of plant will be required. We are making no predictions on that one at this point.

In summary then, if markets can be found for the additional hulls at a price which will permit the marketing of a 50 percent protein or higher cottonseed meal at price differentials which will permit the use of the higher protein products in feeds for nonruminant or monogastric animals, specifically the pig and the chicken, we feel that the use of cottonseed meal produced from good quality seed can be increased considerably, and certainly there is an advantage to having a broader base of usage for any product that we are marketing. The production of protein isolates involves a change from a crushing process to a more complex chemical process.

## PRODUCTION AND MARKETING TRENDS AND POSSIBILITIES FOR FUTURE DEVELOPMENT

by

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The objective of this paper is to evaluate some of the trends in production, merchandising, and utilization of cottonseed protein and to consider how these trends may influence the future market position of cottonseed protein concentrate.

### Comment - Trends Known

Many of our considerations here are necessarily based upon the assumption that the level of cottonseed production will continue to be sufficiently high in the critical years ahead to support a strong and healthy crushing industry.

It appears desirable in this regard to review briefly cotton production trends, but I shall attempt to avoid encroaching upon Dr. M. K. Horne's subject of the factors which can be expected to affect the production of cotton, and thereby cottonseed, in the future.

Federal crop control programs have exerted many effects upon cotton and cottonseed. However, it is quite apparent that beltwide trends in harvested cotton acreage have been more closely associated with the pressure of those controls than have trends in total production. During the 1950-54 period, harvested acreage averaged nearly

23 million acres and production averaged about 14 million bales. In the most recent period of 1961-65, harvested acreage was effectively controlled and averaged about 14.6 million acres and production averaged nearly 15 million bales. Total domestic production in 1965 was about 8 percent higher than the 1950-54 average and it was obtained on 40 percent fewer acres.

Even though most expect the trend to higher acre yields to continue, there is an element of pessimism within the crushing industry regarding the immediate future of cottonseed production; thereby, doubts may exist on and the need to improve our market outlets in the future. There may be some value in reminding ourselves that in the last decade we have had two crops -- 1957 and 1958 -- when production was only about 11 million bales. In three other years of the postwar period there have been three crops -- 1945, 1946, and 1950 -- when production did not reach 10 million bales. Several thoughts may bear on any problem of this nature which the industry may have in any readjustment in the immediate years ahead. Currently, the number of operating mills is about 46 percent of the number in 1950-51 and 74 percent of the 1957-58 number. While there are fewer mills to compete for available seed supplies, it must be recognized that they are larger and that they have heavier capital investment and operating expenses. The second factor is that in many instances poor seed buying practices may have contributed more to business failure than did trends in seed supply available. Finally, there is some merit in considering that it is sometimes more important to improve product unit value during periods of adversity than in periods of prosperity. A profitable enterprise is essentially a two-way street which involves both expense and revenue. Progress in market value of products must not be limited to fair weather conditions.

As we go back to our review of trends, we remind ourselves that the supply of cottonseed has ranged from slightly over 4 million tons to slightly over 6.5 million tons. Oil mills crushed about 81 percent of the production in the 1936-45 period, 91 percent in the 1957-61 period, and about 95 percent of the 1963-64 supplies.

## Processing Trends

As late as the mid-1940's, about 95 percent of the seed were processed with hydraulic equipment. A very strong shift to screw pressing occurred in the next 15 years. A recent Association survey of mills indicates that currently only about 2 percent of the seed are processed by hydraulic presses, 51 percent by screw presses, 25 percent by prepress solvent, and 22 percent by direct solvent extraction.

## Department of Commerce Data

Cottonseed meal was the leading source of domestic protein concentrate until 1942 when soybean meal took the leadership. It continued to make rapid gains until for the current year it is expected that soybean meal will provide 58 percent of the proteins available for feeding while cottonseed meal will provide only about 15 percent.

It is only natural to assume that soybean meal has exerted more competitive pressure on cottonseed meal than has any other commodity. We cannot assume, as many apparently do, that cottonseed meal is the leading protein concentrate for cattle and sheep and that soybean meal utilization is largely limited to poultry and swine. Since 1955 more soybean meal has been fed to ruminants than has cottonseed meal. In 1963 about one-third of the available supply of soybean meal was fed to ruminants and this represented about three-fifths of their oilmeal consumption. In comparison, about two-thirds of the cottonseed meal supply was fed to ruminants and this represented about one-third of their oilmeal consumption.

This loss of leadership in ruminant feeding is clearly a function of the much abundant supply of soybean meal and is not a reflection upon the usefulness of cottonseed meal for cattle and sheep. Ruminants used 57 percent more protein in 1963-64 than for the average of the last three years of the 1940 decade. Animal units fed increased 24 percent and rate of consumption per unit increased 13 percent. The total amount of cottonseed meal fed to ruminants roughly remained constant, but the average amount fed per animal unit decreased about 21 percent.

During the last decade, some important gains have been made in use of cottonseed meal in nonruminant rations because of more knowledge from research and the interest stimulated by it, and because of the quality control and promotion efforts of some mills, primarily those located in the soybean meal deficient areas of the western states.

#### Long-term Level

In 1953 only about 8 to 9 percent of the cottonseed meal supply was fed to poultry and swine. Ten years later this percentage had increased to 27 percent. There appears to be good evidence that this trend is continuing but we must recognize that it has been and still is founded primarily upon a lower cost per unit of protein from cottonseed meal. This conclusion is supported by (1) price comparisons, (2) apparent attitudes of most cotton oil mills toward quality control for nonruminants, and (3) reactions of feed manufacturers.

#### Prices

U.S. Department of Agriculture quoted prices for January 25, 1966, showed that soybean meal was 109 percent of the price of cottonseed meal per unit of protein at Atlanta and Fort Worth, 108 percent at Memphis, and 128 percent at California locations.

#### Mill Attitude

The vast majority of cotton oil mills appear to be giving relatively little consideration to factors which are related to use by poultry and swine. Our survey of mills indicates that only 16 percent of the mills, representing about half of the total production, were confident that they knew the free gossypol content of their meal. A smaller number -- 12 percent representing 27 percent of production -- estimated the nitrogen solubility percentage of their meal. Only 2.5 percent -- representing 12 percent of production -- estimated lysine availability values of their meal. I hasten to point out that this cannot be assumed to be a justified criticism of the alertness of mills. I interpret it to mean that mills are confining their efforts to those values which affect their current market demands, still thinking of cattle feeds.

#### Mixer Attitudes

Our observations indicate that in many areas feed manufacturers are not asking for a cottonseed meal of special characteristics and that when they use cottonseed meal in nonruminant feeds it is on the basis of small percentages and lower price than soybean meal. In many instances this use appears to come from the supply purchased for ruminant feeds without special attention to gossypol content or availability of protein for nonruminants. Some difficulty has been experienced in the Western States in getting manufacturers to accept 50 percent protein cottonseed meal at a price which would justify its production instead of 41 percent or 44 percent.

#### Merchandising

Available information confirms the conclusion that the marketing of cottonseed meal by mills is a picture of contrasts. Our recent survey indicates that about 48 percent of the meal is first handled by a broker or dealer and many mills have little, if any, local sales. Yet, many mills sell almost all of their meal to local livestock producers. There has been a steady growth in percentage sold to feed manufacturers. The best available information indicates that 21 percent of the meal was sold to feed mixers in 1947. Our survey shows that this percentage has now probably reached about 52 percent of total production. This observation coincides well with the rapid growth of the feed manufacturing industry and it has caused concern among some mills which have believed that they could sell more profitably directly to the livestock producer. This trend is not surprising when one realizes that few of those mills which are anxious to sell direct have the distribution system or the magnitude of sales effort to compete with the promotion of prepared supplements or complete feeds. It may be of interest here to observe that our survey indicated that only 17 percent of the mills representing 23 percent of production reported they do some advertising.

#### Characteristics

Along with utilization trends, we need to understand any changes which have occurred in the characteristics of cottonseed meal. In

prewar periods a rather considerable amount of 36 percent protein meal was produced, especially in the Southeast. In other areas 43 percent protein was more or less common. As you know, the protein percentage has stabilized well at 41 percent in most areas. About 6 percent of the total volume is still 36 percent meal and there is some 44 percent or higher protein meal produced in the Western States for the poultry feed trade. The early meals were also high in fat with the analysis running from 5 to 8 percent. Now we can expect the one-half of the supply processed by screw presses to range from 3 to 4 percent, and the 47 percent processed by solvent extraction to range from one-half to one and one-half percent fat. The marked shift to screw presses reduced the free gossypol content from about 0.08 to 0.02 or 0.03 percent. Usually free gossypol may be very slightly higher at 0.03 to 0.05 percent for prepress meals which make up about 25 percent of the supply. The direct solvent meals are considerably higher in free gossypol at 0.20 to 0.40 percent. Generally, we can assume that the solvent meals are fairly high in amino acid availability which is important to nonruminant animals.

#### Comment on Use Values

We consider that urea is a very serious threat to both cottonseed and soybean meals. Its appeal is strictly cost reduction per unit of complete balanced ration and per unit of animal product produced. While it must be used with care, the scientific literature provides abundant evidence that it is an efficient source of nitrogen for animals with a functioning rumen. In a recent review, L. V. Curtin concluded that there is evidence to show that urea may be used satisfactorily to provide 25 percent of the nitrogen for beef cattle rations and up to one-third of the nitrogen in the grain mixture fed to milk cows. We need to understand fully the significance of the use of urea at the levels discussed. In an average 12 percent protein fattening ration for cattle, cottonseed meal may provide about 46 percent of the ration protein. A 16 percent protein dairy mixture may use cottonseed meal to provide up to 60 percent of the nitrogen. Substitution of urea at the satisfactory levels would mean that use of cottonseed meal would be reduced by 65 percent in the fattening ration and by 55 percent in the dairy feed. We must reflect seriously upon those losses.

U.S. Department of Agriculture estimates that in excess of 210,000 tons of urea may have been used for feed in 1963. When combined with grain at about the rate of 1 pound of urea and 6 pounds of grain to replace 7 pounds of protein concentrate, this would be equivalent to about 1.5 million tons of cottonseed meal. The U.S. Department of Agriculture and a major producer of urea have both predicted that use of urea may exceed 300,000 tons in 1970. This will be equivalent to 2,100,000 tons of 41 percent protein cottonseed meal.

A "Feedstuffs" magazine survey of feed manufacturers indicates that the volume of urea-containing supplements has risen about 20 percent in the last 2 years. A "Feedlot" magazine survey of commercial feeders shows that about 71 percent of that group had used urea and that 84 percent of them believed it was worthwhile.

Urea supplies only nitrogen and must be used with carbohydrate concentrates such as grain or molasses. Therefore, the upward trend in grain production provides a favorable environment for the expansion of urea use.

We should not be very optimistic that we can export natural proteins for ruminant use when they are replaced domestically by urea. While the United States has increased its urea production capacity from 1959 to 1966 by 177 percent, other countries have increased their capacity from 192 to 1,020 percent.

We have seen how domestic consumption of protein has increased dramatically without significantly depressing prices. The U. S. Department of Agriculture has presented data to support the conclusion that this was possible because a tremendous protein deficit existed and it concludes that it has now been eliminated and that further increase in domestic consumption must come from increased animal numbers rather than increased feeding rates. Of course, this does not preclude use of meals to provide energy source rather than to provide protein. This situation is tremendously important to cottonseed meal because it has little way to move in such a price squeeze. Obviously, cottonseed meal greatly needs more freedom in markets other than cattle and sheep feeds.

There is good reason to assume we can continue to manufacture protein concentrate as we do now and still expand its feed markets. Dr. Phelps' paper has called attention to one approach. Another is to devote more attention to selling the merits of cottonseed meal even for use in limited quantities. Those who sell cottonseed meal, whether they be mill personnel, brokers, or others, need to have the best possible information on its characteristics and on the total needs of the different feeds being manufactured; and they need to use that information aggressively. No longer can we afford the luxury of letting cottonseed meal sell itself. If any of us have had a past tendency to "soft-pedal" the use of cottonseed meal until such time as we reach the point that it can be used in unrestricted amounts, we had better change our thinking. The time has come to consider that when the price is right, cottonseed meal has a place in every feed mixture. Half of the laying hens and 89 percent of the broilers are fed in the West, South Central, and South Atlantic States. Increased use of cottonseed meal in these feeds at a level of 5 percentage points would extend the market demand by about three-fourths of a million tons. We are firmly convinced that there must be more information pressure up and down the line on all types of usage of products as we produce them now. I do not want to be misunderstood.

I am not in any way suggesting that the sales manager for a mill or its broker is not working at the job. They work to sell and they sell hard. I am saying that somehow we have failed to provide enough people with an understanding of how information on the characteristics of the product can be used to sell. I cannot help but reach this conclusion when I observe that apparently 85 percent to 90 percent of the mills are not informed on how their meal analyze for certain characteristics which are affecting its sale.

I have attempted to make a strong appeal to do better than we are doing with what we have. However, I want to be completely frank and realistic. I do not believe we can ever achieve the maximum market position which is so important to this industry until we are able to correct certain quality deficiencies which are restricting usage, which Dr. Watts discussed, and until we develop basic information on qualities which affect new uses such as those discussed in H. L. Wilcke's paper. The approach to these problems must be two-fold. First, well-planned research needs to be conducted with efficiency and dispatch. Second, industry needs to keep itself informed on the progress of this work and to constantly evaluate the findings to make a sound business decision on whether, when, and how it may use this information to improve its position.

## THE ECONOMIC OUTLOOK FOR U.S. COTTON

by  
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(Presented by D. S. Wellford)

Let's begin with the 10-year record of the U. S. cotton disposed of in the market--1956-57 through the current season, 1965-66--domestic mill consumption and exports.

For the present season the current U. S. Department of Agriculture estimates are 9.5 million bales for domestic consumption and 3.5 million for exports.

Our carryover in 1956 was 14-1/2 million bales, a record high. In 5 years we reduced it by half, or to 7.2 million. But in

these latest 5 years, the carryover has been rising at an even steeper rate; and if these offtake figures are correct for the present season, it will reach about 16-1/2 million bales, a new high, next August 1.

Looking on to the future, we know that this carryover has to be reduced and a way has to be opened for the farmer to grow more cotton, rather than less. This means we have to get a sharp improvement in the market trends that we have had for the past decade.

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If American textile consumption continues to grow as it has during the past 5 years, and if American cotton just maintains its present share of that growing market, domestic consumption will trend upward across the next 5 years by an average of nearly 1/2 million bales each year.

If cotton can merely hold its present share of the foreign fiber market, and if the expansion of foreign cotton production can be held under reasonable restraint, the trend of our export market can increase by an average of some 600,000 bales a year, subject, of course, to big fluctuations up or down in individual years. We'll go into that projection later.

On those simple assumptions, our total market could grow by more than 1 million bales a year--and in 5 years the total would have risen above 18 million bales.

How realistic is that projection? What does it assume?

First, it assumes that the world economy will go on growing at about the average rate that has prevailed now for many years. That looks like a reasonable assumption.

There is only one other thing that we have to assume; namely, that we will begin meeting our competition. The competitors with which we need to be chiefly concerned are rayon, the noncellulosics such as nylon and Dacron, and foreign cotton. To get this result we don't have to force any of these things back to smaller markets. We don't have to stop them from sharing in the future market growth. All we have to do is to bring it about that from this time forward cotton will merely hold its present share of the fiber market and that foreign cotton growers will expand no faster than they have the past 3 years.

We might do better than that. I don't see how we can do less than that if we are to have a healthy cotton economy. So what will it take to meet this competition?

Many people, whether right or wrong, tend to think first about price. So let's look at the price of cotton.

Under the two-price system the mills paid much more than the export price, but under the Agricultural Act of 1964 the

available price to the domestic mills and for export became the same. The price for domestic consumption was sharply reduced, and one-price cotton was restored.

The Act of 1965, which goes into effect next August 1 for a period of 4 years, provides that next season the support price of middling inch shall be 21 cents, and the release price 10 percent higher, or 23.1 cents.

For farmers planting 87-1/2 percent of their allotments the 2 government payments will total 8-1/2 cents per pound on projected yield--so as an indication of what they will get per pound we have plotted this range 8-1/2 cents higher than the 21 to 23.1 cent range. For other farmers the payments will go to various higher levels.

For the three seasons following 1966-67, the law provides that the support price shall be no more than 90 percent of the average world market price--and we know that the general level of the world price itself tends to be governed by the U. S. export price. How can we summarize the effect on farmers, the domestic market, and exports?

(1) In recent years the farmers themselves have taken some big price reductions on most of the cotton produced. For next year, the farmer's situation simply defies description in any brief report, and I won't attempt it. The return he receives per pound is not really comparable with that of prior years, because in general (except for "small farmers") it has to be accompanied by costly reductions in acreage. (Of course the cost of these cutbacks will fall with extra force upon the processors of cottonseed and handlers of cotton.)

(2) The price of cotton for domestic consumption has come down to a level where few if any voices are raised any more to say that it is not competitive in price. It is quite competitive, and it has already been at this level for the better part of 2 years.

(3) The export price can still be undercut by foreign sellers, and they have been undercutting us with a very special urgency this season. That's because of prevailing ideas about the price outlook for the future. But on the basis of what is already apparent now, the surest effect of this price outlook seems to be that it will have a tendency to put restraint on foreign cotton producers

as they think of expanding their acreage.

Let's keep the latest part of the price record before us. It seems to be a fact that, at the combined expense of the farmer, of the whole cotton industry, and of the government, American cotton is becoming a very strong competitor in terms of price. If price were the only factor, our overall competitive outlook for the next few years would be very strong--but we know that price isn't the only factor, and never has been.

The three great factors in fiber competition are research, promotion, and price. So what of research and promotion?

We have approximate ideas of the amount of money invested in research and promotion in this country last year--and first, research. For the manmade fibers it was around \$135 million. This is the approximate amount spent solely upon these fibers by the firms that manufacture them. The amount spent for cotton was about \$26-1/2 million, and this was from all sources combined, both governmental and private. This is a big sum of money in itself, but far out of line with what it takes to be competitive in today's fast-moving fiber technology.

And in promotion, here are the comparable figures. Seventy million dollars for the manmade fibers against about \$4 million for cotton. There is, of course, a lot more involved than just the amount of money being spent. But regardless of how good the cotton fiber is, and of how well these cotton programs are being conducted, it is very obvious that cotton is not getting enough support to counter all these programs, which are being used today to push the synthetics. Up to this point, the efforts to make cotton competitive in price have been vastly greater and far more costly than the efforts to make it competitive in research and promotion. And with what results?

On our domestic market the results are now quite vivid. First we'll take rayon, and show rayon's percentage share of the total fiber market provided by the U. S. textile industry. Over the latest 4 years there was a marked rise and then a marked decline in rayon's share of the market.

The explanation is not hard to find. The Agricultural Act of 1964 was passed in April of that year. It lowered the price of cotton to the domestic mills quite sharply, and as a result, rayon's competitive gains were halted and turned back. We have now had enough time to give that situation a real test, and there is no ground to doubt that price was the main cause of this.

But our problem comes when we look at the other main class of manmade fibers--the noncellulosics--fibers such as nylon, Dacron, and Orlon. These fibers were gaining upon us before the price of cotton came down, and they have kept right on gaining at about the same rate after it came down.

Now why the great difference in the performance of rayon and of the noncellulosics following the reduction in the price of cotton? The difference comes out sharply when we look at prices per pound. For rayon the list price is still 28 cents, but it can be bought for substantially less. I am putting 27 cents as a rough indication of the average price being paid for first quality staple from the domestic suppliers. This is not comparable with the price quotations on cotton, because this is a delivered price, rayon has a lower waste factor, and so on. But this is comparable with these prices for Dacron, Orlon, and nylon, which are 80 cents or more.

Rayon gives us our closest test in price competition, and we have pushed rayon back. But our recent losses have been to the non-cellulosics, which have much higher prices, but a great advantage over us in research and promotion.

All three factors are always at work. Prices of the noncellulosics, high as they are, are lower than they used to be, and they are going to be lower still. Rayon, with its lower price is also backed by some research and promotion, but the really great efforts in research and promotion have been those of companies like Du Pont, Chemstrand, Celanese, and Eastman, in support of the noncellulosics. They have made these gains mainly with research and promotion, and they can't be permanently checked unless we meet them on that field of competition.

Now we'll look at the actual amount of fiber consumed by the U. S. textile industry.

This begins with 1958 and goes through the last quarter of 1965. First, we have the amount of cotton consumed. Why hasn't it had a better rise in recent years, when the total amount of textile fiber consumption, expressed in cotton equivalents, has had a much more rapid rate of increase? Who got this rapidly expanding market?

Not wool or rayon. Rayon did gain in the earlier years, when its percentage share rose from 15.8 percent in late 1960 to 20.2 percent in early 1964. But after the price of cotton came down, rayon's share of the total dropped back to 17.8 percent.

Obviously the big problem is the other main type of fiber--the noncellulosics--moving into our markets with their great programs of research and promotion. They have doubled their market in the past 3 years. They have now reached an annual rate equal approximately to 6 million bales of cotton--and remember that this leaves out their tire cord market. This is the main thing holding us down. We've got to meet this competition in order to get any long-range expansion in the cotton market.

The noncellulosic fiber manufacturers have already announced that in staple fiber alone they will increase their annual capacity over the next 2 years by about 2 million additional cotton bale equivalents. In noncellulosic staple and filament combined, including tire cord, the increase will equal almost 5 million bales. And there are comparable expansions underway in a number of foreign countries.

Even if these manufacturers continue to gobble up markets at the rate of the past few years, it would seem that they are headed toward a lot of excess production capacity, and this might have quite an effect on their prices and their profits, but the question for cotton to face is: Are they actually going to keep on gaining markets at our expense like this? We don't have to submit to this, if we'll take realistic action against it.

The most notable invasion of our markets in the past year has been with synthetic-cotton blends, exploiting the concept of Durable Press. But today the whole textile market is keenly aware of the prospects that all-cotton Durable Press fabrics may achieve a big comeback in the next year or 2. This is the kind of thing that cotton has to

accomplish if we are to check some of these synthetic gains and have our own market begin to share fully in the overall textile expansion. For cotton to follow through and actually make big market gains here, and keep on making them in the face of the massive research and promotion which will continue to be used against us--we have to move up rapidly to much bigger research and promotion efforts of our own.

Now we'll glance at the highlights of our competition in the export market.

For the Free Foreign World we will consider the production of cotton from 1956-57 through the present crop year, as currently estimated. From 1959-60 and 1962-63 there was a big increase in foreign production. It rose more than 5 million bales, and that was a major blow to U.S. exports. But across the latest 3 years, the pace of expansion has slowed down quite remarkably--a net increase of less than 1 million bales in 3 years, if the estimate for the current season is correct. Both acreages and yields have shared in this slowing-down.

In cotton consumption, in the same Free Foreign World, the big damage to our basic export position came in the 1959-60 and 1962-63 period, when a spurt in foreign production was accompanied by a leveling off in consumption, and the spread between production and consumption was reduced to about 2 million bales, where it has remained, approximately, up till now.

The demand for cotton in the Free Foreign World also includes the amount required to supply the net exports to communist countries. Present estimates indicate that the spread between this total demand and the amount of cotton produced will be about 4 million bales--about the same as last season--but that U.S. exports will fall short of that 4 million because of a workdown in foreign stock holdings.

Let's look again simply at production and consumption.

The trend of Free Foreign cotton production over the next 5 years may merely continue at the average rate for the last 3 years (an increase of some 360,000 bales per year). The chance that it might be held down to no more than this mild rate of increase seems to be supported not only by

recent experience but also by the outlook for world cotton prices which seems to be indicated by the Agricultural Act of 1965. Variations in yield, of course, could push production well above or below this in individual years.

But even with this relatively small increase, our outlook for exports is very bleak indeed unless something can be done about the trend of cotton consumption in the Free Foreign World. Obviously consumption might even dip below the production line in a few years. If we are to have an export market, a sharp improvement in foreign consumption is required. Is this possible?

If cotton can just stop losing markets competitively to other fibers, and can begin holding its present share of the foreign market, the consumption trend will turn upward by around 1 million bales a year, on average. And in spite of a mild increase in foreign production, we could build up our exports by an average of some 600,000 bales each year. That's what we have to do, and it requires us to give primary attention to the foreign competition of cotton with other fibers.

The consumption of the main textile fibers in the Free Foreign World across a recent period of some 8 years bears a lot of resemblance to the domestic market. The total consumption of fibers, expressed in cotton equivalent, is expanding very strongly through the years, but cotton consumption is not sharing very much in that improvement. The big gains in the fiber market are not going to wool or to rayon, but again to the noncellulosics. Most of this gain, let me add, has been concentrated in Western Europe and Japan, the countries to which most of our cotton exports go.

There is little room to doubt that the world textile market will go on trending upward through the years. The question we face is whether we are going to permit the noncellulosic fibers, riding upward on greater research and promotion in spite of a higher price, to go on taking nearly all the market increase. Their consumption increased by 1.7 million cotton bale equivalents in 1964 over the previous year. We don't have the figures yet on 1965. But if over the next 5 years they continue increasing their market by that same rate of 1.7 million a year, they will get nearly all of the gain in the total fiber market. What chance would cotton have

to get much improvement out of the remainder, which would be growing very little.

But if these noncellulosics can be forced to take only their pro rata share of the future expansion, their part of the market will increase at a far lower rate, and cotton will have every reason to get the lion's share of the growth in foreign consumption. That would make our exports boom. Whether the noncellulosics go on taking most of the increase in the fiber market or whether they are held to their present share will turn on the success of the big effort, which is now well advanced, to bring in a great deal of supporting money from other producing countries for cotton promotion abroad, and more fundamentally it will depend on whether we in the United States can demonstrate cotton's ability to meet the challenge of research and promotion right here at home.

The economic future of cotton is always surrounded by a whole range of problems and challenges:

--- Lower costs and better quality--we now seem to have 4 years in which to push ahead here, and to prepare for the political uncertainties that lie beyond that period.

--- The big threat of higher labor costs, which might be imposed not only by government but also by the law of supply and demand.

--- The threat of payment limitations under the cotton program, which could wreck all of cotton's chances. One of the best ways to hold down that danger is by making our markets expand.

--- "Feed the World" is a phrase which has recently taken on a great new meaning. I need not spell it out for you. "Food for Peace" is a more dignified term for it. If our national agricultural policy is to take a new direction, with much greater emphasis on feeding hungry foreign populations, exploding upward in size, where will American cotton come out? This could be one of our most critical questions. Many of those foreign countries are growing a lot of cotton now. Will our policy cause them to shift from food to cotton, or from cotton to food, in the emphasis of their own agricultural production? The faster we move forward with technological progress in our own cotton operations, the more sense it will

make for our cotton to play a great part in whatever farm products this nation decides to supply to the world's destitute millions in the future.

Whether we talk about meeting synthetic competition directly, or about these or various other closely related aspects of the America cotton problem today, the challenge which is central to the whole thing now is Research and Promotion. If we cannot rise to this, American cotton is through, for practical purposes. If we can get greatly expanded, effective programs here, and get them without delay, we have a great potential for economic health and progress.

Let me close with this look at the fundamental nature of our cotton problem. The main fibers which compete with us are polyester fiber (such as Dacron, Fortrel, Kodel), acrylic fiber (such as Orlon, Acrilan, Creslan), nylon, acetate, and rayon. As fiber producers, we are still a lot bigger than all of them combined.

Who makes these competing fibers? Who is the biggest in each case? The Du Pont Company makes over half the polyester, over half the acrylic, nearly half the nylon. Celanese about two-thirds of the acetate. American Viscose (or FMC) nearly half the rayon. These proportions are all in a state of constant change, and we have to estimate these company figures, but the estimates are based on a great deal of careful research. One company has about half of all the noncellulosic.

What about Chemstrand? When you add it, you see that two companies control about four-fifths of the acrylic and two-thirds of the nylon. Chemstrand is also going into polyester, as are various other companies. When we add a section for Celanese under polyester, we see that two firms control nearly four-fifths of that.

And finally we see how many companies make all or nearly all the rest--three in polyester, three in acetate, four in acrylic, five in rayon, and six in nylon. A few are currently being added, but in every case a small handful of corporations produce all or nearly all the fiber. For each company there is a board of directors who can sit down around one table and allocate for research and promotion whatever amount of money they think is needed to build long-range profitable

markets for their company. In this day of modern fiber marketing, that is why their sales are trending up and up and why most of their gain is coming right out of the cotton farmer's market.

Now how many separate enterprises produce cotton in this country? Hundreds of thousands.

There is the very heart of the cotton problem. It is why we don't have a research and promotion program today that is big enough to give cotton a fair chance in modern competition. It's why the life or death of the cotton market now turns on whether these producers can get an effective mechanism to marshal some of the resources of this great economy to do the job.

And this is the reason for the efforts now underway to get enabling legislation that will permit cotton producers to decide whether they will impose on themselves a levy of \$1 a bale to get the kind of research and promotion programs that are needed to meet our competition.

## DISCUSSION

Question: Mr. Wellford, looking at your charts there, you referred to support price of 21 cents. Of course, that is the loan price?

Mr. Wellford: Yes.

Question: Your curve indicated a world price of something above that. What do you estimate that to be in the export market?

Mr. Wellford: Let's put this chart back up there if I can find it right quick. I don't believe we indicated any actual price for the future. We simply showed here the range between the support price.

Question: Well, without putting the price back up, the point I was trying to clear up is that the export world market, the world market on cotton, is somewhat higher in the loan value.

Mr. Wellford: Yes.

Question: Therefore, a farmer who chooses to go the 87-1/2 percent route, might well expect 24 or 25 cents plus a support price

of 8-1/2 cents for his cotton when sold, is that correct?

Mr. Wellford: Well, the support price, as you say, is 21, but remember that cotton is going to be available from government stocks at 10 percent above that price, which is 23.1 cents, so it would perhaps seem unlikely that with the government holding 12 million bales or more cotton that the price could go very much above the release price.

Now, of course, it could if the quality of cotton in government stocks is not the kind of cotton that the mills and exporters want. In this case, of course, the price for the desired qualities could go above the release price.

Question: Well, is it not a reasonable assumption that cotton will sell at something above loan value?

Mr. Wellford: Yes.

Question: Or is it your expectation that the principal part of next year's crop is going into the loan?

Mr. Wellford: I think that it is most likely that the average price will be above the loan price. How much above, of course, is subject to almost anybody's guess.

Question: Well, on that basis then, it's reasonable to assume that on the standard grade of cotton, the man who takes the 87-1/2 percent route might expect something in excess of 30-1/2 cents for his cotton price.

Mr. Wellford: I think this is very possible, yes.

Question: One other question for clarification. As I jotted these figures down from your charts, it seems as though the man-made fibers are bringing in the market a little bit more than double the price of cotton, the cost of cotton, is that correct?

Mr. Wellford: The noncellulosics?

Question: Yes.

Mr. Wellford: Yes. Of course, there are some things such as lower waste, transportation costs being included in the quoted price, etc., that bring the actual cost to the mills somewhat closer together than this, but still, it's very obvious that these prices are definitely higher than the price of cotton.

We have an advantage in price, without a doubt.

Question: We have heard for a good long while that cotton was not competitive in the domestic market, and yet in some instances here, we are competing with a product that sells for 80 cents as against cotton bringing 35 cents.

Mr. Wellford: Yes. Of course, the main competitive factors in these cases are factors other than price. Quality and promotion are much more decisive.

## RESUMÉ OF TOPICS DISCUSSED AT PREVIOUS CLINICS

by

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Until recently, I assumed I had friends on the clinic program committee. But when I was assigned the present talk "Resumé of Topics Discussed at Previous Clinics" (a total of nearly 200 presentations) and to do this in about 20 minutes at the end of what otherwise has been an instructive and enjoyable program, I decided I had to resort to strategy.

So I dutifully reviewed the previous clinic proceedings and found that many of the subjects were discussed at several meetings so that the total number of different subjects was about 30 to 35 (depending on the grouping you used) and, of these, slightly more than 20 would cover the more important subjects.

I have prepared a thumbnail resumé of these more important subjects and have had these mimeographed for distribution. That gets me "off the hook" and now I can talk on just a few subjects and perhaps tell you a story or two.

Webster gives the following definition of "Clinic"--An institution usually connected with school, court, or settlement, in which concrete cases or problems of a special type are studied, and expert advice or treatment given; as a vocational, child guidance, or psychiatric clinic."

The Cottonseed Processing Clinics have been the forum for the discussion of many processing problems of the cottonseed oil industry. The presentations made and the open panel discussions have enabled everyone to contribute out of his experience to a further elaboration or a solution of the problem.

Sometime ago, I asked myself--"What is the most important problem facing the cottonseed oil industry?" and my answer was that the cottonseed oil industry was uncertain about the future. I tried to analyze the elements of this uncertainty, and here is what I came up with.

(1) Cottonseed production is positively linked to cotton production. Mr. Wellford has just discussed that in an able manner.

However, the supply of cottonseed does not in all areas limit the size of the mill. Soybeans are a second crop in many cottonseed areas. Other crops include peanuts, sesame, flax, corn and wheat germ, safflower, and rice bran. Of course, there are geographic limitations to the handling of some of these cropcombinations. Also, processing equipment must have sufficient versatility to handle the differing raw materials.

(2) The important consideration, however, is not how much cottonseed or other oilseed material is processed each year but what are the objectives of that processing. I will have to explain what I mean. Everything that is done in the oil mill is eventually evaluated in a profit and loss statement. A better way of stating that would be--everything that is done has an important effect on the profit and loss statement. It also has an effect on the future of the oil mill.

Let us look at this in more detail. When the mill is operated to produce oil, meal, hulls, and linters, and the products are sold, there is a certain revenue each season. From this, one would subtract the cost of the seed plus all items of expense in the mill, in the office, for taxes, insurance, interest, depreciation, brokers' charges, and so forth. The difference between the revenue and the costs is the profit for that season. That is elementary. You will notice in the formula just quoted there is no reference to product quality or processing method used. The future of the oil mill is involved in the quality of its products.

Everyone knows that with any given type of processing--screw pressing, prepressing, and direct solvent extraction--the processing conditions used affect the quality of the products, the capacity of the mill, and the costs.

How many mills know if they are making the highest quality products, at the best commensurate daily capacity and cost?

I have noticed that the differential in favor of soybean meal between soybean meal and cottonseed meal quoted in the Memphis, Tenn., terminal market, and calculated on an equal protein basis has been gradually increasing. Does this mean that the buyers in this area in which both cottonseed meal and soybean meal are produced are placing a relatively higher value on soybean meal than on cottonseed meal? It probably does. Must this continue? I don't think so.

Methods are now available to produce high quality cottonseed meal substantially equal to soybean meal as demonstrated by feeding tests. Why aren't these methods being employed by the oil mills? Why haven't some of the mills displayed enough interest to demonstrate their feasibility? Wouldn't this result in cottonseed meal higher in value--approaching soybean meal?

(3) Meat, milk, fish, and eggs are the principal sources of protein in our diets. There are those who say this will change in years to come. To what extent can we continue to devote a high percentage of our land area to animal raising and cultivation of the crops required for feed and fodder? Must we, ere long, get our nutrition more directly from cereal crops, and legumes, plus

protein concentrates derived from oilseed meals?

Famine, starvation, and death are imminent in many areas of the world that have a high population density. Furthermore, cereal grains and pulses now largely used in these areas are nutritionally inadequate in human diets unless reinforced by proteins of proper amino acid composition. Should the cottonseed industry prepare now or at least draw up some kind of blueprint or prospectus for the next few decades which contemplate conversion in part or wholly to the production of food grade protein. Dr. Wilcke's presentation covered some aspects of the foregoing subject.

(4) Gossypol is still a highly important problem associated with cottonseed processing. It is responsible for the color problem in cottonseed oil and imposes restrictions on the use of cottonseed meal in the feeding of swine and poultry. Combination of gossypol and meal components by processing (cooking) minimizes the oil color problem but does not solve the nutritive problem for nonruminants.

Over the past few decades several research approaches have been investigated:

- a. Mechanical removal of gossypol pigment glands by flotation of differential settling after controlled disintegration of the flakes in suitable nonpolar solvents.
- b. Removal of gossypol using polar solvents alone or in combination with nonpolar solvents, and subsequent removal of the gossypol from the oil during refining.
- c. Treatment of cottonseed meals (during or after the processing step) with chemicals, such as, amines or iron salts. Dick Phelp's presentation dealt with this subject.
- d. Breeding of glandless (gossypol-free) cottonseed. The last three approaches are presently under active development. If cottonseed is to maintain its position as a major oilseed crop in the United States and in developing countries around the world, it is imperative that the gossypol problem be solved for practical use within the next decade.

(5) Facing the Future. Most large modern industries are faced with continual

change. Automobiles, airplanes, communication, paper, plastics, chemicals, coatings, petroleum and metals are excellent examples. There are many more. The keyword in each of these industries is flexibility. It is the only answer that provides an adequate response to competition. The flexibility of research, development, and quick commercialization are depended on heavily in these industries to meet the threat of lost markets to a new, improved, better and/or cheaper product made by a competitor. Who can say what the real competitor of cottonseed meal is? Soybean meal? Fish meal? Urea or other synthetic nitrogen product? Protein from petroleum, algae, or natural gas? or what?

I am suggesting that an entire session be included in next year's program to be entitled "Facing the Future." This session should be practical, imaginative, informative, self-appraising, optimistic, and constructive. The objectives of the session should be clearly delineated and presentations should be sought from a mill manager, a mill superintendent, a control chemist, an equipment manufacturer, a mixed feed manufacturer, a nutritionist, and an SU researcher. It would be well to persuade suitable speakers to participate in this session and to prepare advance drafts of their presentations for review by the other speakers on the session about a month or two before the next clinic meeting.

#### Resumé of Major Topics Discussed at Previous Clinics in Abstract Form<sup>1</sup>

Cottonseed Storage has received considerable attention. Adequate seed cooling and aeration facilities, continuous monitoring of storage temperatures, prompt processing of high-moisture and off-quality seed, and storage of good seed for long periods are included in the recommendations. In the face of the mycotoxin problem, it may be necessary for mill operators to revise some of the above procedures.

Mechanical Pressing now accounts for about 54 percent of cottonseed processing. The hydraulic method accounts for only about 8 percent. The future of screw pressing would appear to depend as much upon the quality of the oil and meal products (especially for possible human food) as upon high

<sup>1</sup> This section was issued as handout at the time of Mr. Gastrock's presentation.

capacity, low residual oil, and operating costs.

"Hidden Oil Losses" do exist as was reported by the late Jim Brawner and his committees. There is practically no "unaccounted for" oil loss in solvent plants, very little to no loss in hydraulic mills; but when hydraulic mills converted to screw pressing, the "unaccounted for" loss increased by about 6 pounds per ton of cottonseed processed. The analytical determination of residual oil in seed and meal is not absolute but is dependent upon the moisture content of the sample, the solvent used, and the temperature and time of extraction.

Prepress Solvent Extraction accounts for about 30 percent of cottonseed processing in the United States as compared with about 16 percent for Direct Solvent Extraction. The recent decision of one operator to substitute additional cooking and rerolling through regular flaking rolls for the prepressing step may set a trend here.

Filtration-Extraction is now used commercially for the extraction of rice bran, sunflower seed, rapeseed, flaxseed, and press cake, in addition to cottonseed and soybeans.

Mixed Solvent Extraction has been developed on a pilot plant scale to the point where it is considered ready for commercial use. Considering the low total and free gossypol contents and high nutritive value of the mixed solvent-extracted meal and the increased yield of neutral oil, the costs could be competitive with conventional processing.

Exhaustive Extraction of flakes prepared by simple flaking and tempering showed decreasing percentages of neutral oil and increasing percentages of oil impurities in successive extract fractions, whereas with cooked flakes the high percentage of neutral oil was maintained to the end and the dollar value of the oil extracted was highest of the three methods of preparation.

Protein Control to be effective must receive attention at every stage of the processing from the linter room to the final grinding, mixing, sacking, storing and shipping. Although control of operations in the huller room is considered the heart of the problem, final adjustment of the protein content occurs in the grinding and mixing operations. Every effort must be made to keep the

composition of all streams of cake, meal, hulls, and bran uniform and to have meaningful chemical analyses.

Cottonseed Cleaning and Linters have been discussed in great detail at nearly every clinic meeting. Although improvements have been made from year to year in cottonseed cleaning and in the linting operation itself, linters are still in trouble in the market place as a result of competition from wood pulp in the chemical field and from foamed products in the upholstery field. An improved batting using a mixture of first-cut linters and cotton waste treated with latexes and thermosetting resins is now getting increased acceptance in the automobile upholstery, furniture, and bedding fields.

Cottonseed Oil is the most important product of cottonseed processing, dollarwise, and color is its most important problem. Miscella refining has solved the color problem in several mills. Bleaching with activated alumina has been demonstrated on pilot-plant scale as a potential solution for offcolor oils.

Cottonseed Meal for Animal Nutrition. The use of the lowest possible temperatures during cottonseed processing and the maintenance of the highest possible epsilon amino free lysine values, together with low free gossypol and high protein quality, have opened up new outlets for cottonseed meal in broiler rations. Current efforts to overcome the effects of gossypol by lysine supplementation, use of iron salts or by solvent removal of gossypol (mixed solvent extraction) are the major current lines of attack on the problem.

Cottonseed and Peanut Flour of acceptable quality could be a major contribution in feeding the world's hungry millions. Cottonseed and peanuts are grown in most of these critical areas. All of the processing "know how" utilized in producing highly nutritive animal feed products from cottonseed can be adapted to producing food grade materials in sanitary installations. Solvent processes such as the mixed solvent process are under serious consideration for gossypol (and mycotoxin) removal with hopes for the future pinned on glandless (gossypol free) cottonseed.

Glandless Cottonseed has been heralded as the ultimate solution of cottonseed's most

serious problem--gossypol. The breeding program has progressed steadily but firm predictions as to the sole use of glandless cottonseed in any one region or the entire belt are not available.

New Edible Oil Products such as aceto-glycerides used as food coatings and confectionery fats used as replacements for cocoa butter have been developed from cottonseed oil. Cottonseed oil might be considered as a source of palmitic acid for products requiring this fatty acid. The high price of cottonseed oil is a deterrent to its industrial use.

The Presence of Mold Toxins is potentially the most serious quality problem which faces the producers, manufacturers, and handlers of food and feed products. It could become a problem for all agricultural commodities, not just cottonseed and peanuts. The broad objectives of SU research are: (1) to develop analytical methodology, (2) to determine the effect of graded levels of aflatoxin on various experimental animals, including farm animals, (3) to find practical methods for preventing or at least minimizing mold growth in our commodities, and (4) to develop processes for removing or destroying toxins in those lots of our commodities that may have been contaminated with toxin producing molds.

Available Lysine is presently considered the critical amino acid in cottonseed. (There may be others.) The amino acid compositions and availabilities of the meal proteins are of highest importance in increasing the utilization of cottonseed meal as feed for poultry and

swine, a market now limited for cottonseed.

Cottonseed Versus Soybean Meal. There are no restrictions on the feeding of cottonseed meal to ruminant animals but its use for nonruminants is limited, especially for swine and laying hens. Soybean meal may be fed to all animals without restriction. The limiting factors for cottonseed meal are gossypol content, hull fiber content, protein content, and amino acid availability (especially lysine availability). Soybean meal usually sells at a higher price than cottonseed meal for the same protein value. Mild processing conditions using a solvent such as acetone-hexane-water has been shown to yield a cottonseed meal substantially equal to soybean meal based on feeding tests with swine, broilers, and laying hens.

An Impermeable Seedcoat appears to have considerable potential in reducing field and storage deterioration of cottonseed. The condition is genetically controlled and can be selected from commercial varieties as well as wild varieties of cotton.

Seed Protein Pioneering Research at Southern Utilization Research and Development Division is engaged in studying the ultra structure of seed proteins, including the location of oil, protein, enzyme, mineral, and other sites, and changes during storage and germination. The findings should eventually prove beneficial in a practical manner to all phases of the life of a seed crop from planting to utilization.

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